

**Errata for
Water Quality and Hydrodynamic Modeling of
Tenkiller Reservoir**

Expert Report of S. A. Wells

V. I. Wells

and

C. J. Berger

for

State of Oklahoma

in

Case No. 05-CU-329-GKF-SAJ

State of Oklahoma v. Tyson Foods, et al.

(In the United States District Court for the Northern District of Oklahoma)

August 2008

Scott Wells, PhD, PE
Professor of Civil and Environmental Engineering

Because of the rush to meet the Court's deadline, inadvertent mistakes were made in the boundary conditions for the model.

The errata include the following:

1. The chlorophyll a to algae ratio in the input boundary condition was originally 25 µg chlorophyll a/mg organic matter but was not consistent with the model calibration. This ratio was adjusted to 10 µg chlorophyll a/mg organic matter so that the boundary condition and the model were consistent. This change necessitated re-running the calibration and long-term simulations since the boundary conditions were adjusted.
2. The Total P to organic matter ratio for the input boundary condition was originally 1% but was not consistent with the model calibration. This fraction of P in organic matter was adjusted to 0.5% so that the boundary condition and the model were consistent. This change necessitated re-running the calibration and long-term simulations since the boundary conditions were adjusted.
3. The consistency of the model water level after 50 years of simulation was checked early in the long-term simulation model development. After resolving flow rate issues in the linkage between the loading model and CE-QUAL-W2, this check was inadvertently not repeated. A recent check found slight water level drift over the 50 year period. This was adjusted and necessitated re-running the long-term simulations to make sure none of the results were affected by this drift.

Since these changes affected the model inputs for both the calibration and 50 year scenario simulations, as mentioned this necessitated re-running the model calibration and the 50 year simulations. As a result, the report figures and tables that were affected by this change were updated with adjusted results.

In general the model calibration results were essentially unchanged. The 50 year model simulation results also were consistent with the earlier report summary even though there were some refinements in the results.

The tables below show all the figures, tables and text that were adjusted in the report and the reason for their adjustment. As mentioned above, most of the figures/tables had little change from their original figures/tables. The adjusted figures and tables are attached to this erratum.

Table 1. List of adjusted figures.

Figure #	Page # in original report	Reason for adjusted figure
18	21	Illinois River: Updated algae graph – 25 to 10 µg/mg
23	25	Illinois River: Updated Organics graph
28	30	Baron Fork: Updated algae graph – 25 to 10 µg/mg
31	33	Baron Fork: Updated Organics graph

Figure #	Page # in original report	Reason for adjusted figure
36	38	Caney Creek: Updated algae graph – 25 to 10 µg/mg
39	41	Caney Creek: Updated Organics graph
62-66	61-63	Updated Temperature graphs
67-74	73-77	Updated Dissolved Oxygen graphs
75-79	78-80	Updated Total Nitrogen graphs
80-85	81-84	Updated Ammonia graphs
86-99	85-92	Updated Nitrate and Nitrite graphs
100-110	93-98	Updated Total Phosphorous graphs
111-124	99-106	Updated Dissolved Ortho Phosphorus graphs
125-132	107-111	Updated Chlorophyll a graphs
134	114	Updated Light Extinction graph
135-139	115-119	Updated Model vs. Data graphs
143	124	Illinois River: Updated algae graph – 25 to 10 µg/mg
148	127	Baron Fork: Updated algae graph – 25 to 10 µg/mg
151	129	Caney Creek: Updated algae graph – 25 to 10 µg/mg
165-180	148-156	Updated Volume Weighted graphs
181-188	157-160	Updated Frequency Distribution graphs
189-191	165-167	Updated Summer Dissolved Oxygen graphs
192-194	168-170	Updated Dissolved Oxygen Dynamics graphs
195-198	173-176	Updated Fish Habitat graphs
200-202	179-181	Updated Total P Loadings
203-205	182-183	Updated Total P Outflow
212-221	207-215	Updated Temperature Profile graphs
222-232	216-223	Updated Dissolved Oxygen Profile graphs
233-242	224-231	Updated Chlorophyll a Profile graphs

Table 2. List of adjusted tables.

Table #	Page # in original report	Reason for adjusted table
6	60	Updated Temperature statistics
9	74	Updated Dissolved Oxygen statistics
14-21	161-163	Updated Model Run statistics
22	164	Updated Summer Dissolved Oxygen concentrations
25	177	Updated Fish Habitat Volume
27	181	Updated Total P Outflow
28	184	Updated Total P Sediment Flux
29	190	Updated Change in Chlorophyll a
30	190	Updated Change in Total P
31	191	Updated Change in Dissolved Oxygen

Table 3. List of adjusted text.

Page # in report	Original text	Adjusted text	Reason for adjustment
20	25 microgram/mg	10 microgram/mg	Change in model boundary condition for consistency
24	<i>Total Organics</i> : <i>ORG Nitrogen</i> : <i>ORG Phosphorous</i> (100: 8: 1)	<i>Total Organics</i> : <i>ORG Nitrogen</i> : <i>ORG Phosphorous</i> (100: 8: 0.5)	Change in model boundary condition for consistency
33	Illinois River	Baron Fork Creek	typo
66	In Table 8: AG2:1.9 AS2:0.1	In Table 8: AG2:2.0 AS2:0.3	Changes in model calibration as a result of change in boundary conditions
67	In Table 8: AG3:2.5 AS3:0.0	In Table 8: AG3:2.0 AS3:0.2	Changes in model calibration as a result of change in boundary conditions
72	In Table 8: SODT2: 25	In Table 8: SODT2: 20	Changes in model calibration as a result of change in boundary conditions
115	The overall model absolute mean error of 0.76°C is well below the typically acceptable value of 1°C for an acceptable temperature calibration	The overall model absolute mean error of 0.78°C is well below the typically acceptable value of 1°C for an acceptable temperature calibration	Changes in model calibration as a result of change in boundary conditions
117	For ammonia, model errors were less than 0.15 mg/l	For ammonia, model errors were about 0.15 mg/l	Changes in model calibration as a result of change in boundary conditions
119	Absolute mean error for Total P was 0.025 mg/l (mean error was 0.008 mg/l) while measurements for Total P were as high as 0.47 mg/l with a standard deviation of the field data of 0.058 mg/l. Absolute mean error for dissolved PO ₄ -P was 0.015 mg/l while measurements were as high as 0.093 mg/l and the standard deviation of the field data was 0.014 mg/l.	Absolute mean error for Total P was 0.028 mg/l (mean error was 0.002 mg/l) while measurements for Total P were as high as 0.47 mg/l with a standard deviation of the field data of 0.058 mg/l. Absolute mean error for dissolved PO ₄ -P was 0.018 mg/l while measurements were as high as 0.093 mg/l and the standard deviation of the field data was 0.014 mg/l.	Changes in model calibration as a result of change in boundary conditions

Page # in report	Original text	Adjusted text	Reason for adjustment
164	The trend in the cessation case is an improvement in hypolimnetic dissolved oxygen of almost 0.2 mg/l/year, while the base case continues to have lower dissolved oxygen in the release by about 0.006 mg/l less per year.	The trend in the cessation case is an improvement in hypolimnetic dissolved oxygen of almost 0.02 mg/l/year, while the base case continues to have lower dissolved oxygen in the release by about 0.003 mg/l less per year.	Updated results due to change in boundary conditions and a typo
164	The linear trend for the outlet dissolved oxygen was a reduction of about 0.002 mg/l per year for the growth scenario.	The linear trend for the outlet dissolved oxygen was a reduction of about 0.008 mg/l per year for the growth scenario.	Updated results due to change in boundary conditions
168	In general, the reduction in oxygen demand in the lacustrine part of the reservoir is about 4E7 g/day over the last 10 years	In general, the reduction in oxygen demand in the lacustrine part of the reservoir is about 5E7 g/day over the last 10 years	Updated results due to change in boundary conditions
169	This comparison shows that over time the water column dissolved oxygen demand is reduced by about 3E7 g/day during the last 10-year period by enforcing the cessation scenario.	This comparison shows that over time the water column dissolved oxygen demand is reduced by about 6E7 g/day during the last 10-year period by enforcing the cessation scenario.	Updated results due to change in boundary conditions
170	At the end of the 50-year period the rate of net oxygen production from algae declines by almost 2E8 g/day as P load from the watershed is reduced.	At the end of the 50-year period the rate of net oxygen production from algae declines by over 1E8 g/day as P load from the watershed is reduced.	Updated results due to change in boundary conditions
186	The model accurately predicted temperature profiles within the reservoir with an absolute mean error of	The model accurately predicted temperature profiles within the reservoir with an absolute mean error of	Updated calibration results due to change in boundary conditions

Page # in report	Original text	Adjusted text	Reason for adjustment
	0.77°C	0.78°C	
186	Dissolved oxygen profiles had an absolute mean error of less than 1.5 mg/l, with values less than 1.2 mg/l at several stations.	Dissolved oxygen profiles had an absolute mean error of about 1.5 mg/l, with values less than 1.2 mg/l at several stations.	Updated calibration results due to change in boundary conditions
187	Even with these limitations, the error in chlorophyll a model predictions was within about 15% of the range in measured chlorophyll a.	Even with these limitations, the error in chlorophyll a model predictions was within about 10% of the range in measured chlorophyll a.	Updated calibration results due to change in boundary conditions
189	Even though Total P is reduced by over 50% at the end of the 50 years, the chlorophyll a during the summer is only reduced from 20-36% . For the growth scenario, having a 42% increase in Total P loading resulted in increases in chlorophyll a from 21-43% .	Even though Total P is reduced by over 50% at the end of the 50 years, the chlorophyll a during the summer is only reduced from 27-39% . For the growth scenario, having a 42% increase in Total P loading resulted in increases in chlorophyll a from 20-35% in the lacustrine stations. The LK04 station had a reduction due to increased suspended solids limiting light transparency.	Updated results due to change in boundary
189	The average outlet dissolved oxygen is improved by over 1 mg/l as a result of the cessation scenario.	The average outlet dissolved oxygen is improved by about 1 mg/l as a result of the cessation scenario.	Updated results due to change in boundary conditions
191	Even though the Walleye habitat volume improved, it was still only 4% of the lake volume on average over the 50-year period between June 15 and September 15.	Even though the Walleye habitat volume improved, it was still only 3% of the lake volume on average over the 50-year period between June 15 and September 15.	Updated results due to change in boundary conditions

Page # in report	Original text	Adjusted text	Reason for adjustment
192	For the Cessation scenario, Total P concentrations were reduced by 20% to 35% (depending on the lake station) over the 50-year period.	For the Cessation scenario, Total P concentrations were reduced by 42% to 57% (depending on the lake station) over the 50-year period.	Updated results due to typo (original text should have been 42-52%) and to change in boundary conditions
192	For the Growth scenario, Total P concentrations increased by about 100% to 200% by the end of the 50-year period	For the Growth scenario, Total P concentrations increased by about 130% to 190% by the end of the 50-year period	Updated results due to change in boundary conditions
192	For the Historical scenario, Total P concentrations increased by about 300% to 700% by the end of the 50-year period.	For the Historical scenario, Total P concentrations increased by about 300% to 500% by the end of the 50-year period.	Updated results due to change in boundary conditions

Updated Figures

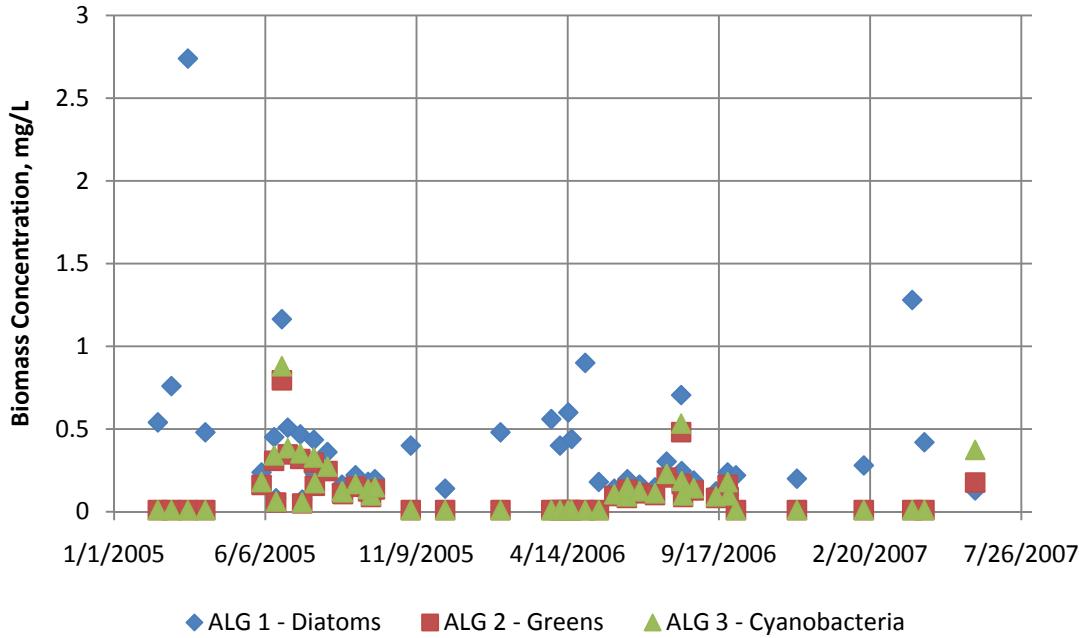


Figure18. Illinois River algae groups during calibration period.

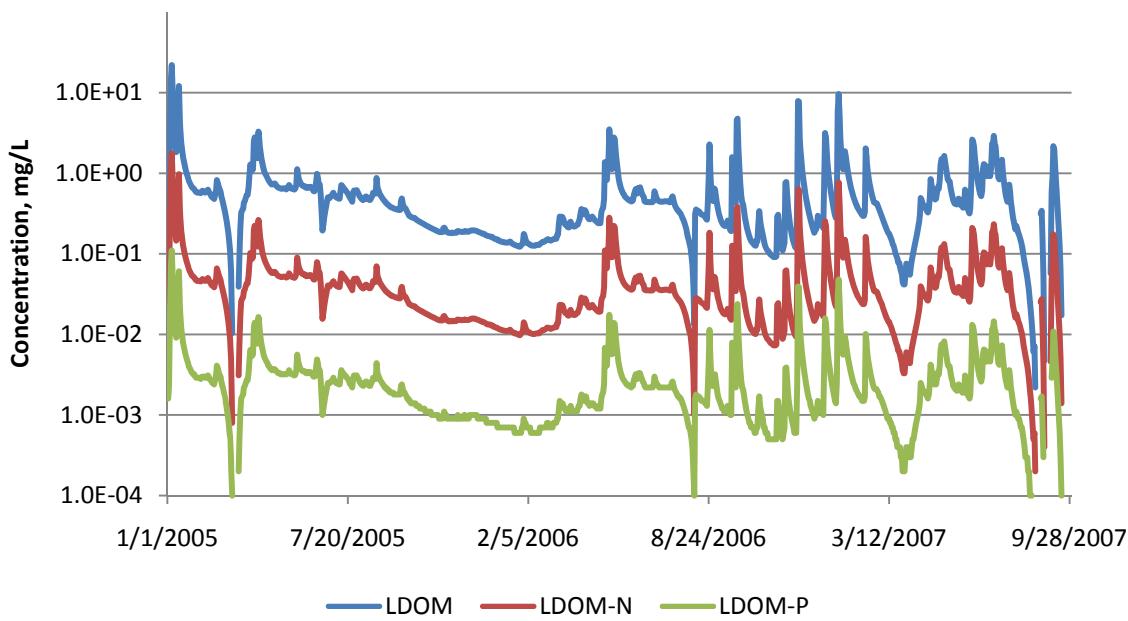


Figure 23. Illinois River organic fractions during calibration period.

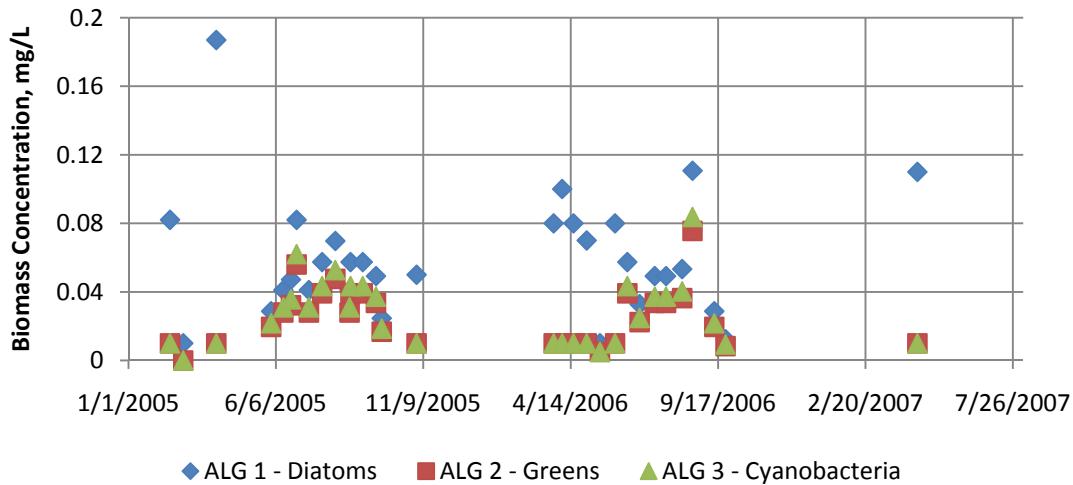


Figure 28. Baron Fork algae groups during calibration period.

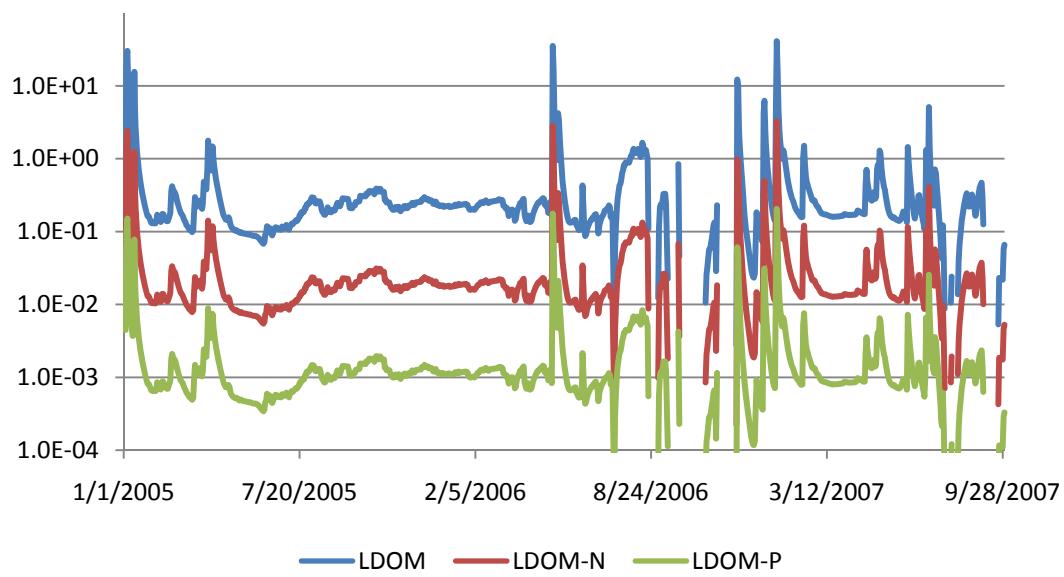


Figure 31. Baron Fork Creek organic fractions during calibration period.

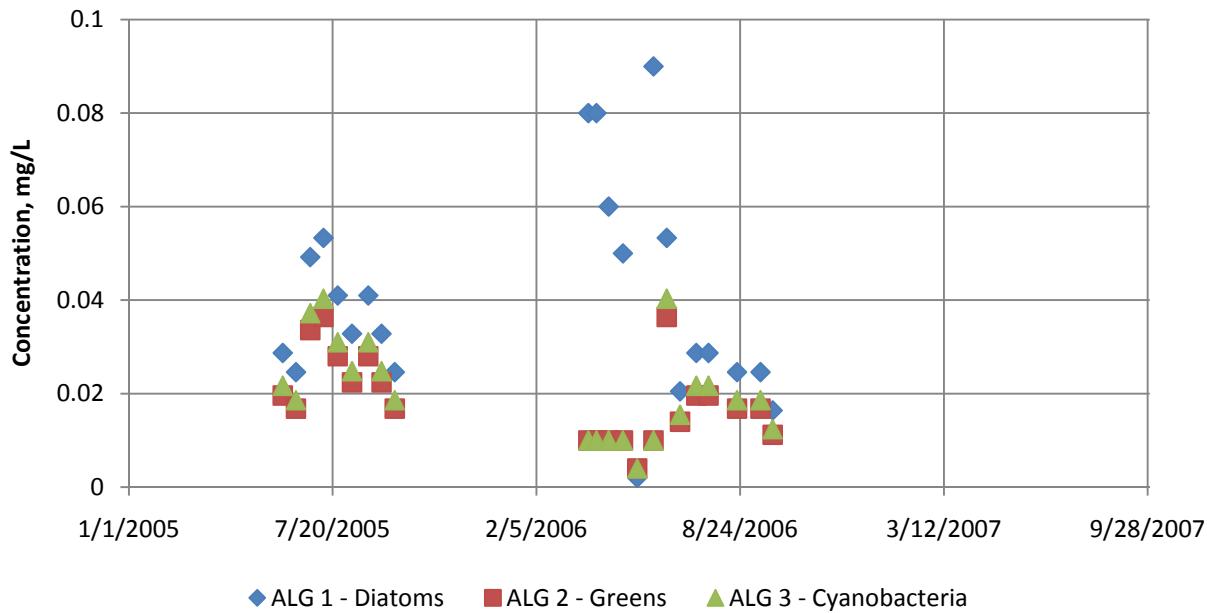


Figure 36. Caney Creek algae groups during calibration period.

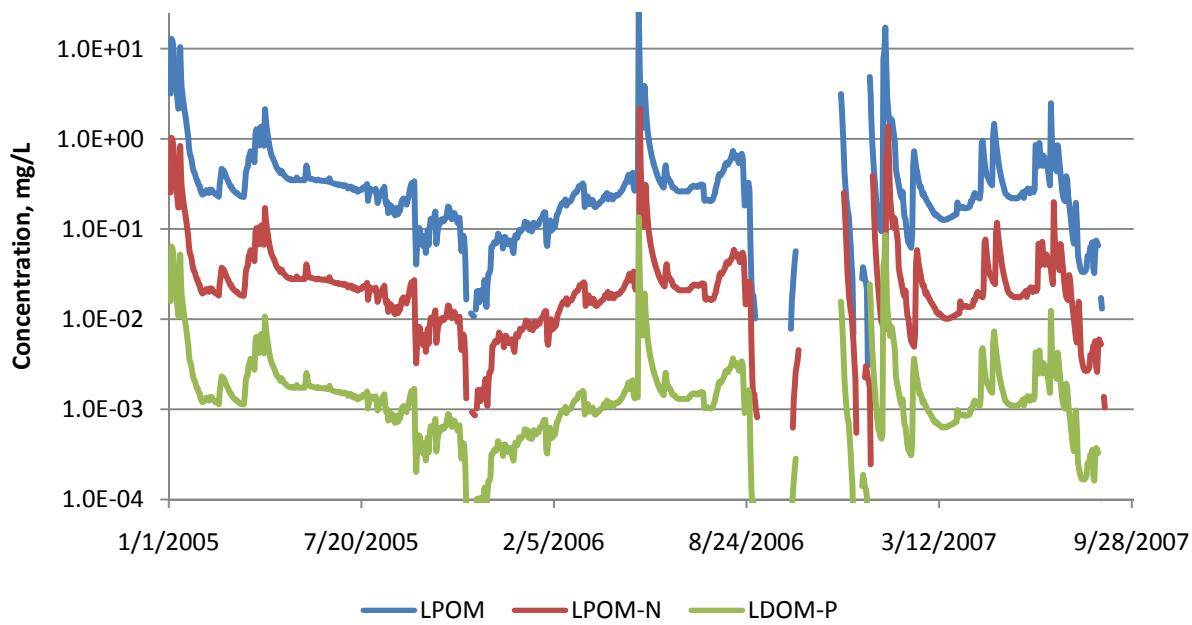


Figure 39. Caney Creek organic fractions during calibration period.

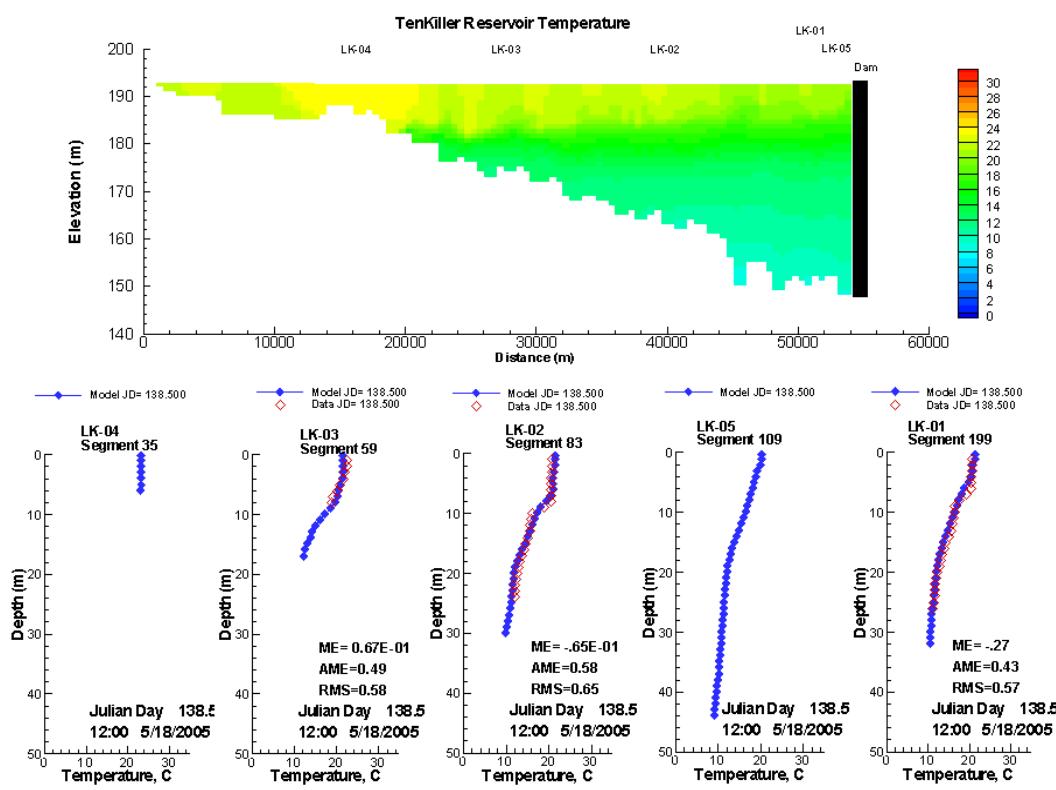


Figure 62. Temperature profiles of model and data for 5/18/2005.

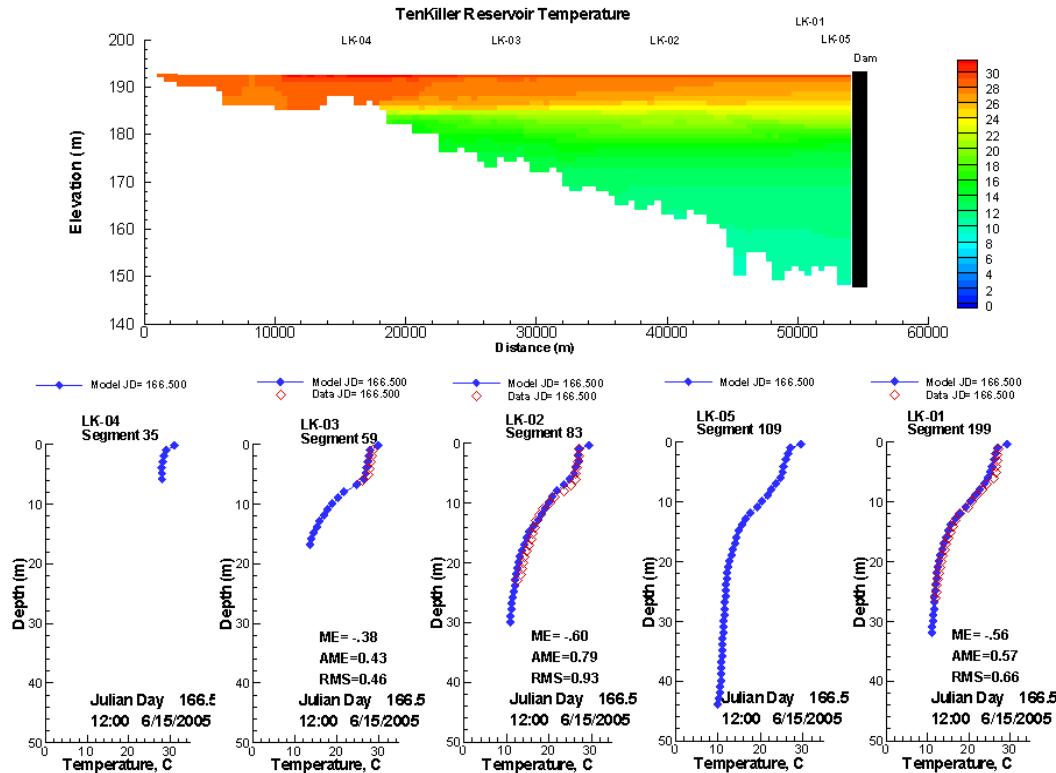


Figure 63. Temperature profiles of model and data for 6/15/2005.

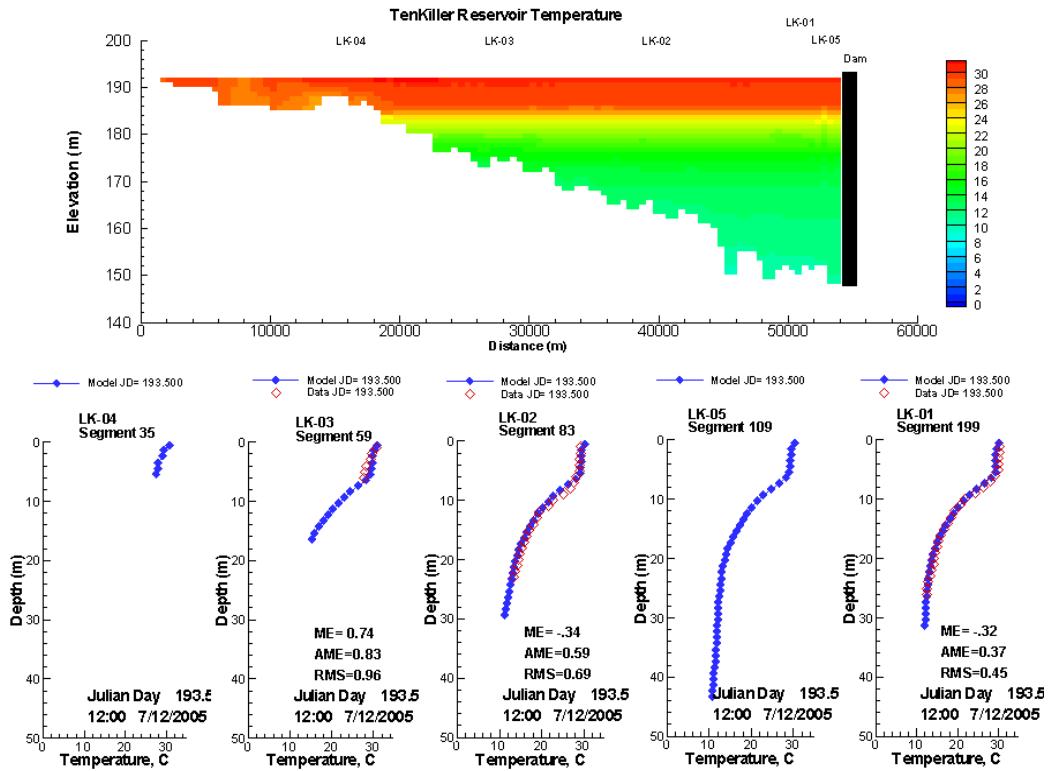


Figure 64. Temperature profiles of model and data for 7/12/2005.

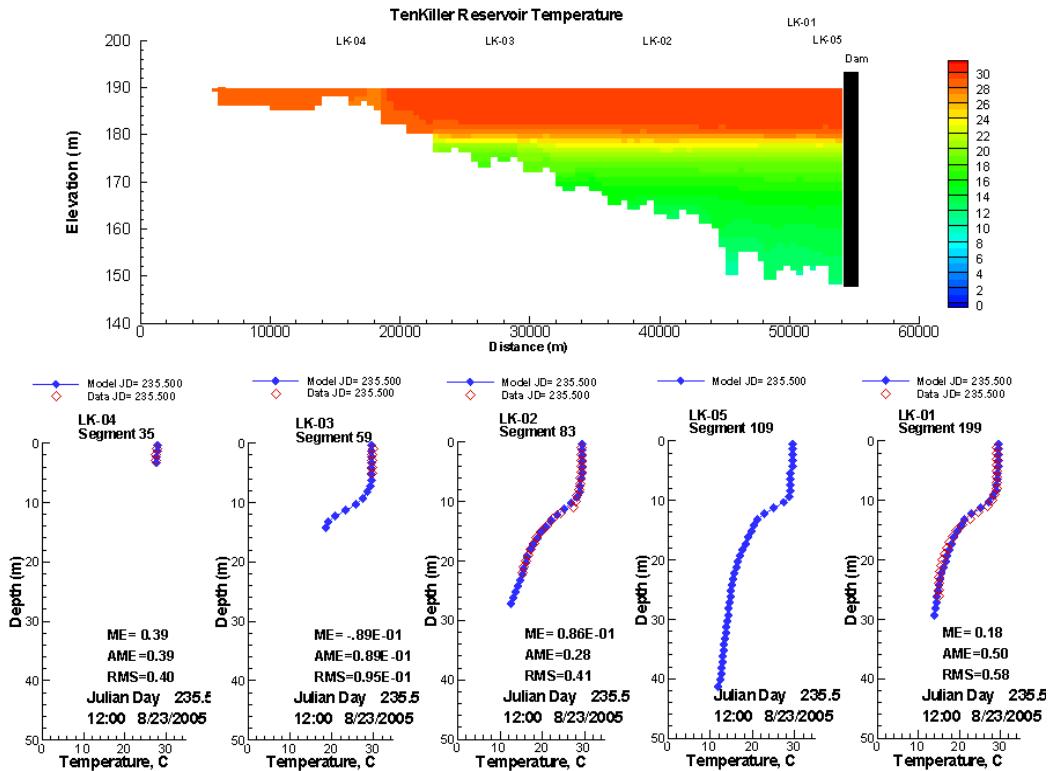


Figure 65. Temperature profiles of model and data for 8/23/2005.

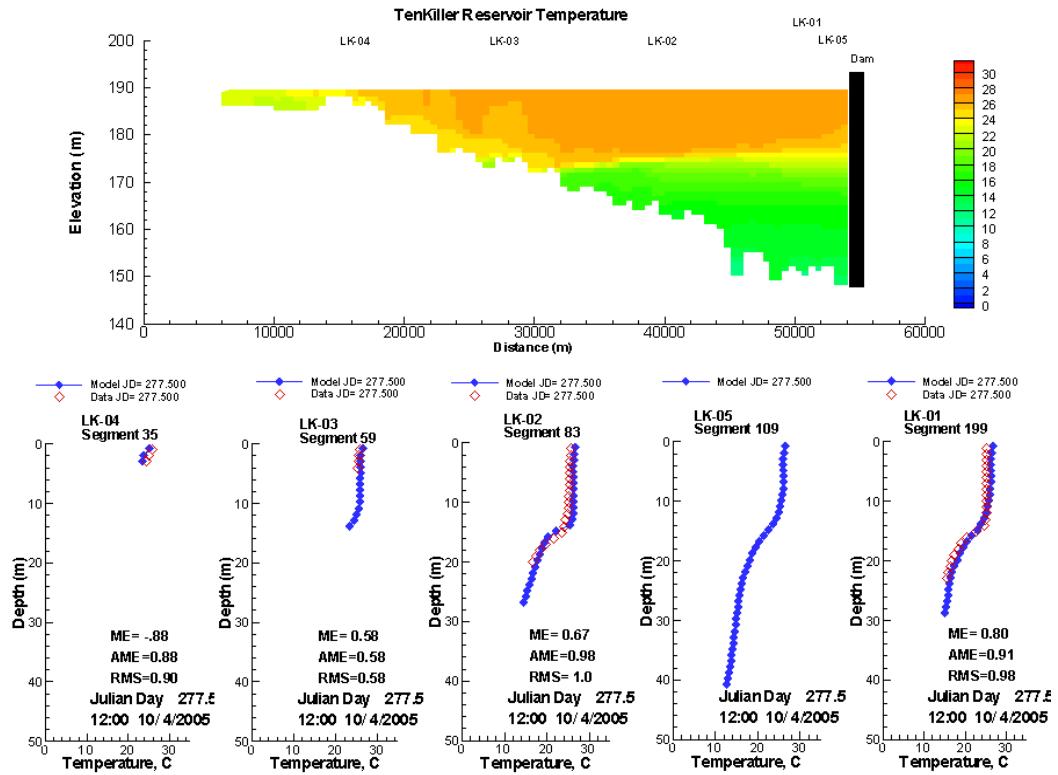


Figure 66. Temperature profiles of model and data for 10/4/2005.

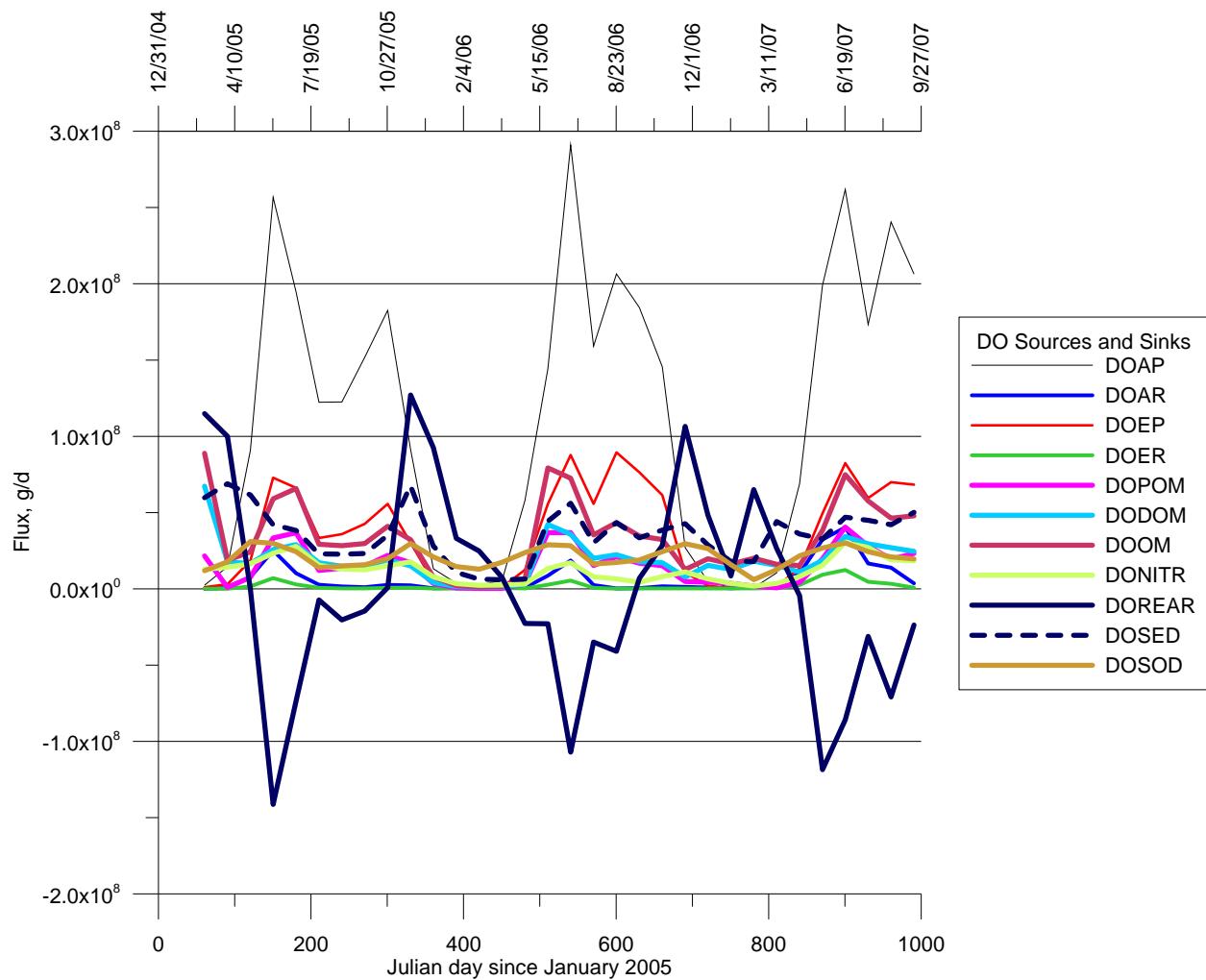


Figure 67. Sources and sinks of dissolved oxygen predicted by the model during calibration period.

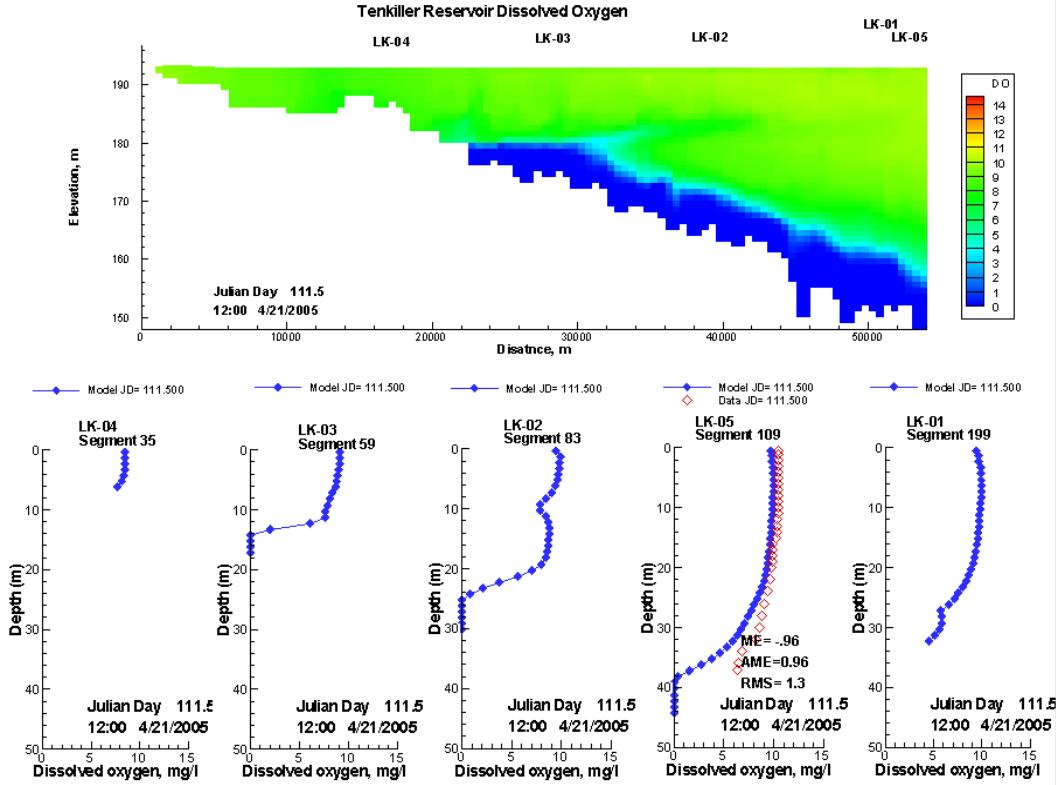


Figure 68. Model predictions of dissolved oxygen profiles compared to field data on 4/21/2005.

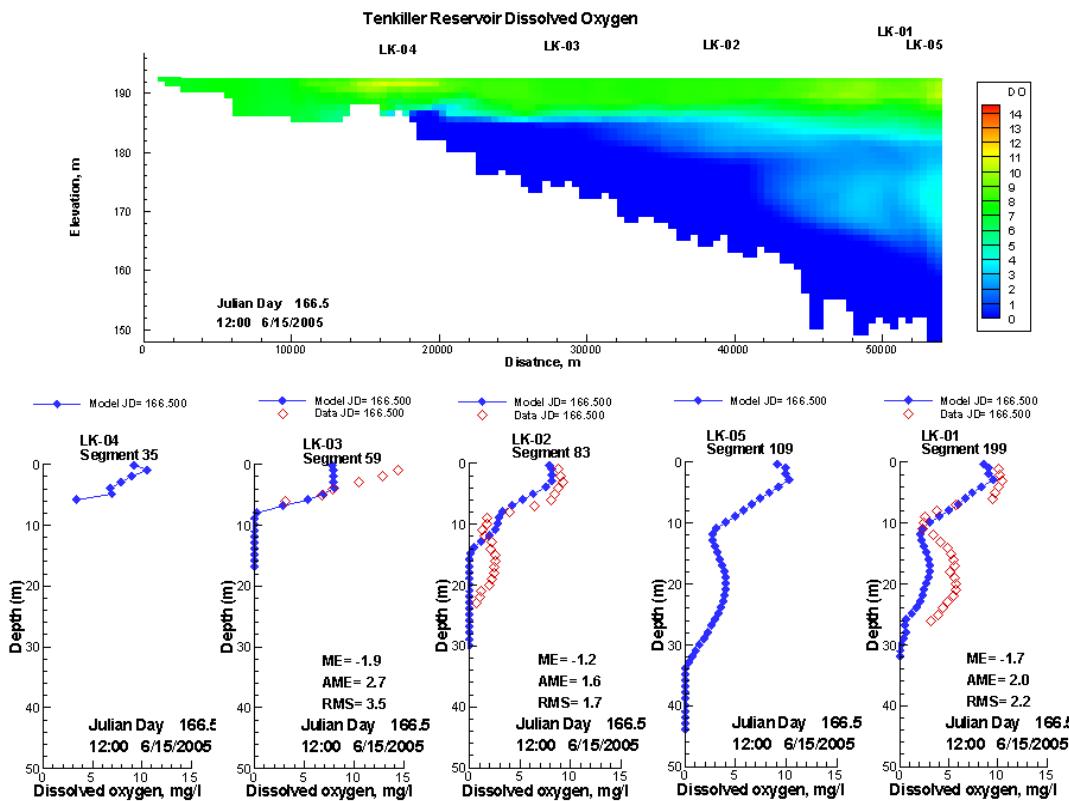


Figure 69. Model predictions of dissolved oxygen profiles compared to field data on 6/15/2005.

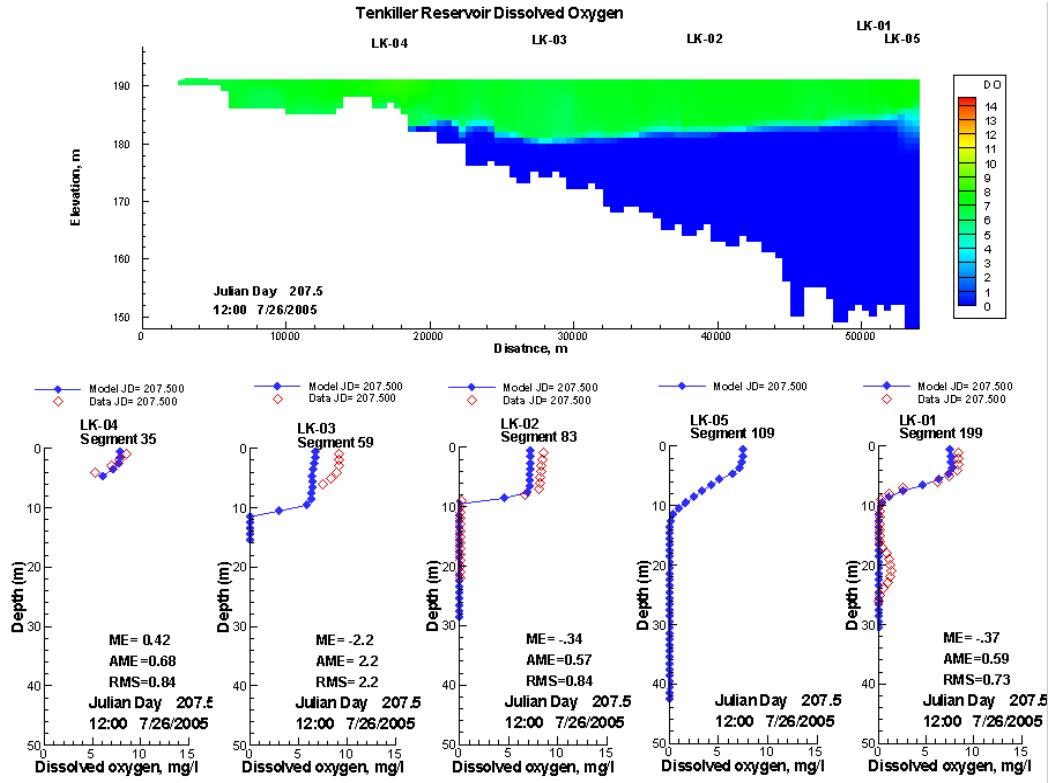


Figure 70. Model predictions of dissolved oxygen profiles compared to field data on 7/26/2005.

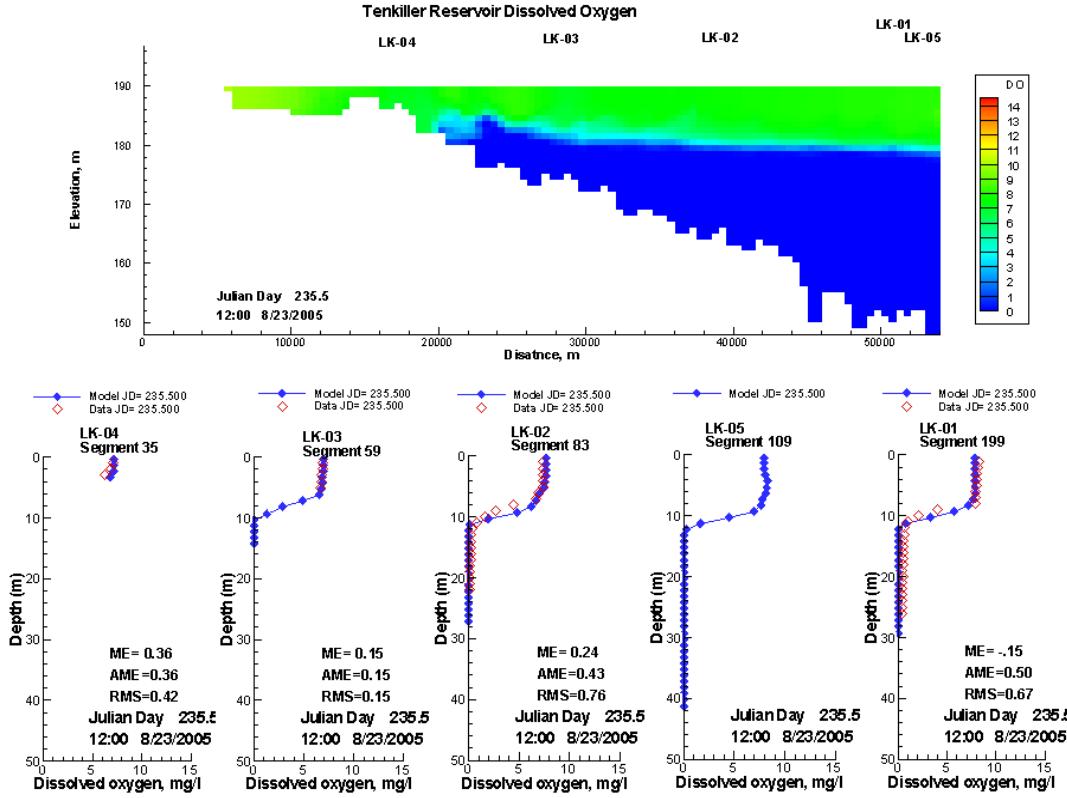


Figure 71. Model predictions of dissolved oxygen profiles compared to field data on 8/23/2005.

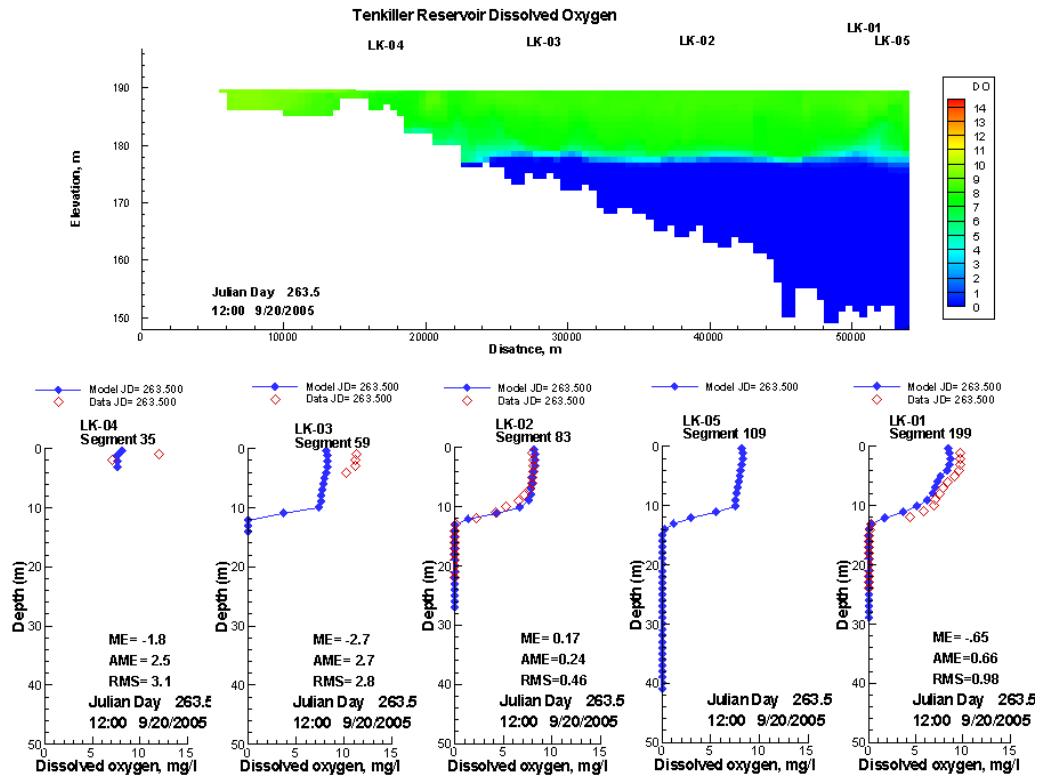


Figure 72. Model predictions of dissolved oxygen profiles compared to field data on 9/20/2005.

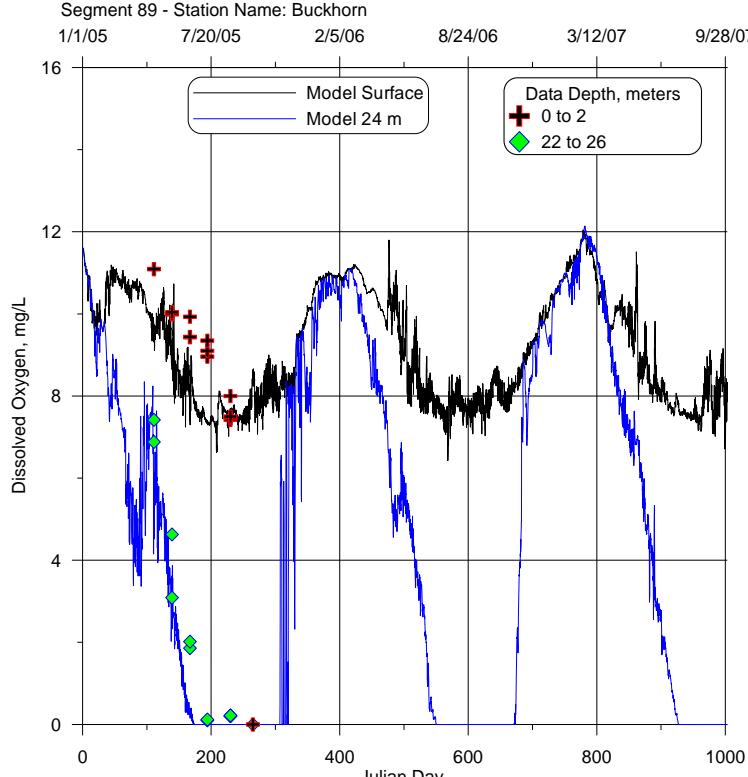


Figure 73. Dissolved oxygen time series - segment 89 during calibration period.

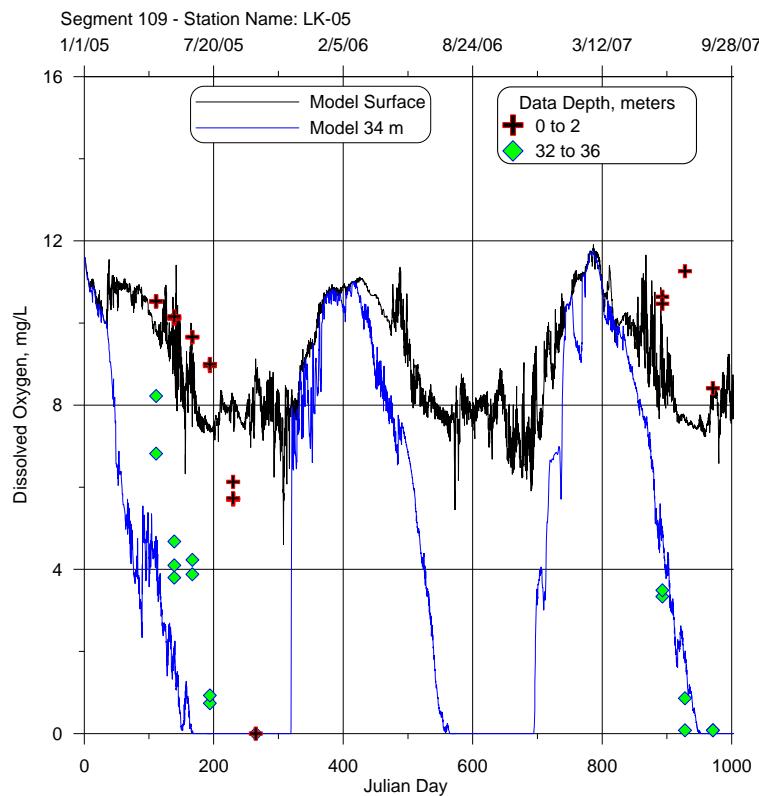


Figure 74. Dissolved oxygen time series - segment 109 during calibration period.

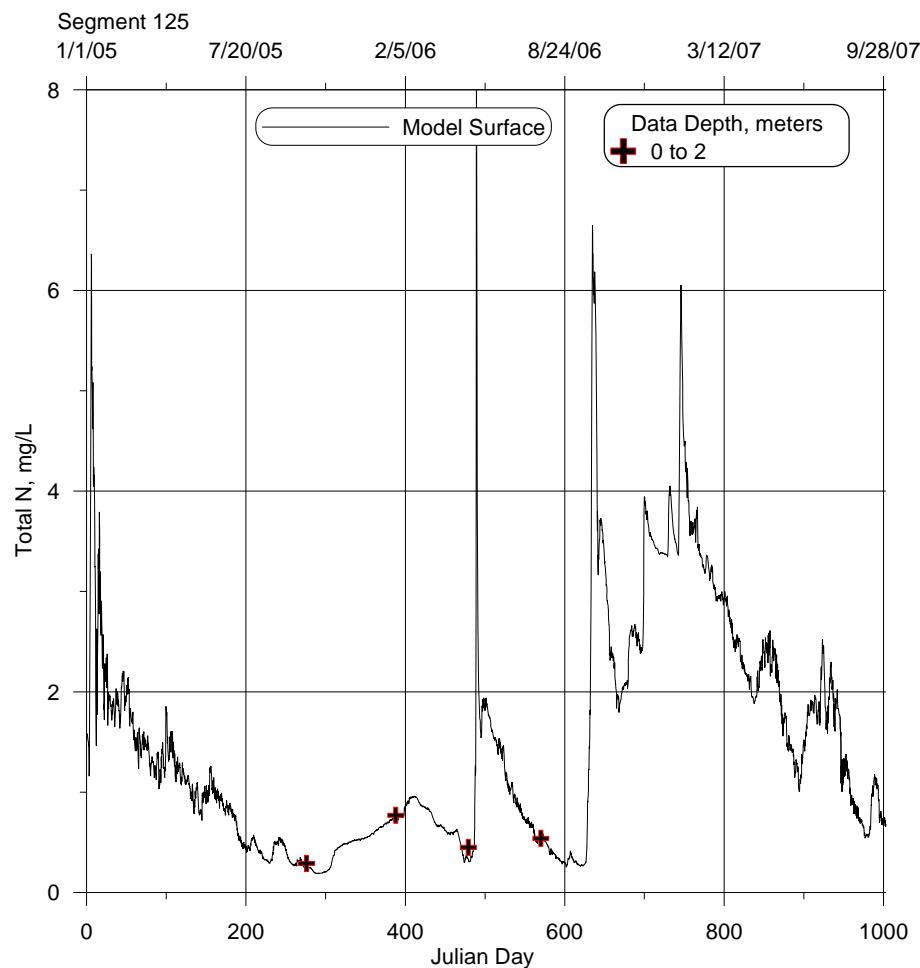


Figure 75. Total nitrogen model vs. data comparison - segment 125 during calibration period.

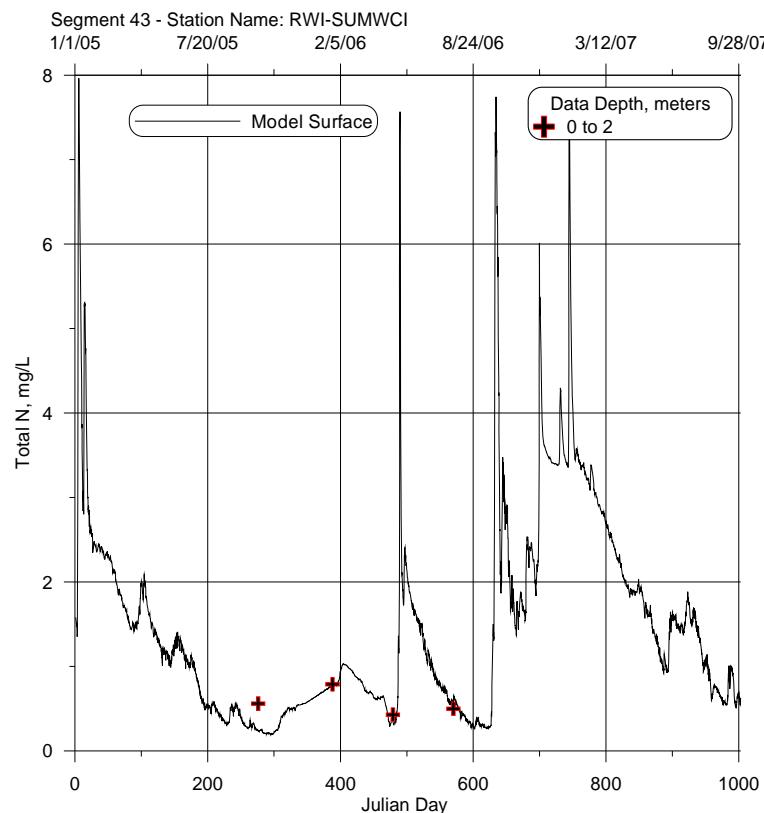


Figure 76. Total nitrogen model vs. data comparison - segment 43 during calibration period.

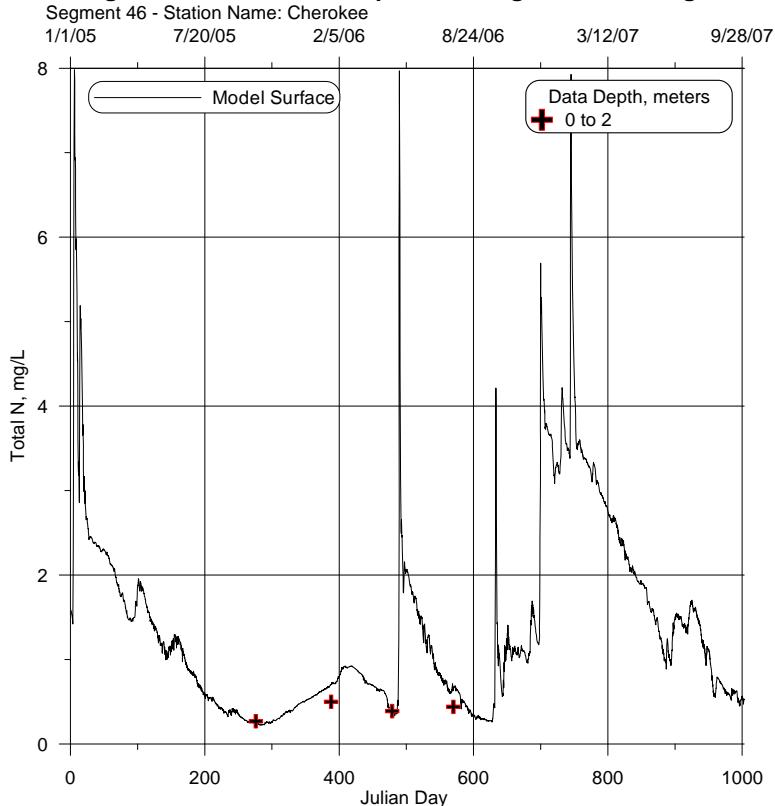


Figure 77. Total nitrogen model vs. data comparison - segment 46 during calibration period.

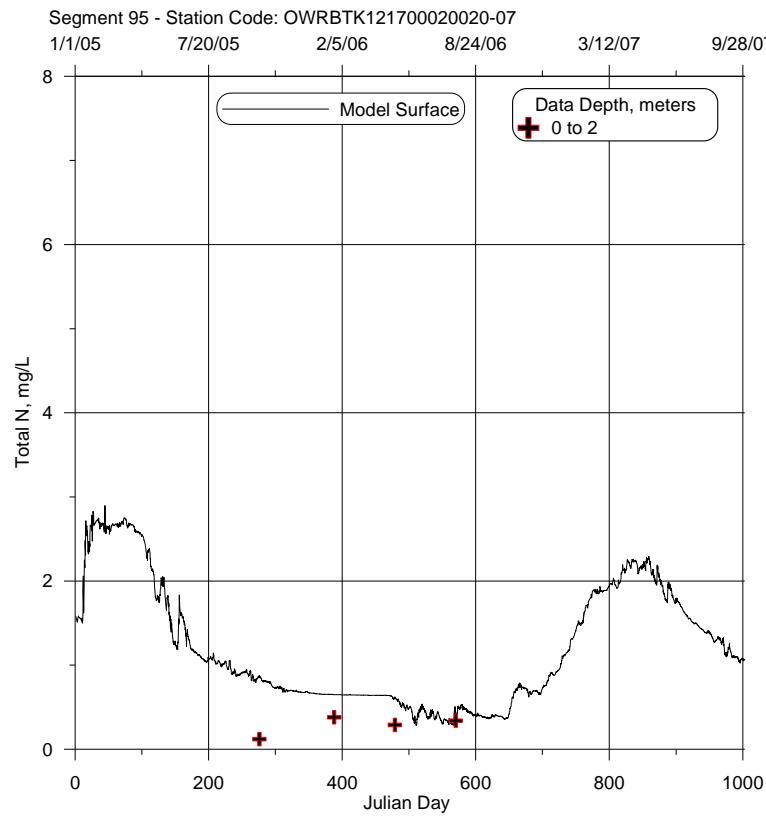


Figure 78. Total nitrogen model vs. data comparison - segment 95 during calibration period.

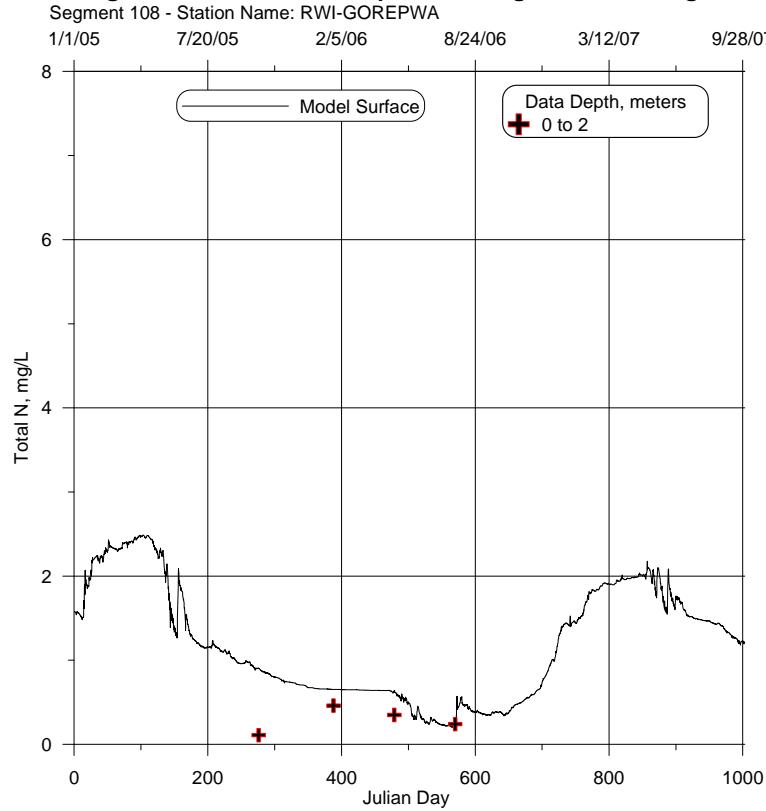


Figure 79. Total nitrogen model vs. data comparison - segment 108 during calibration period.

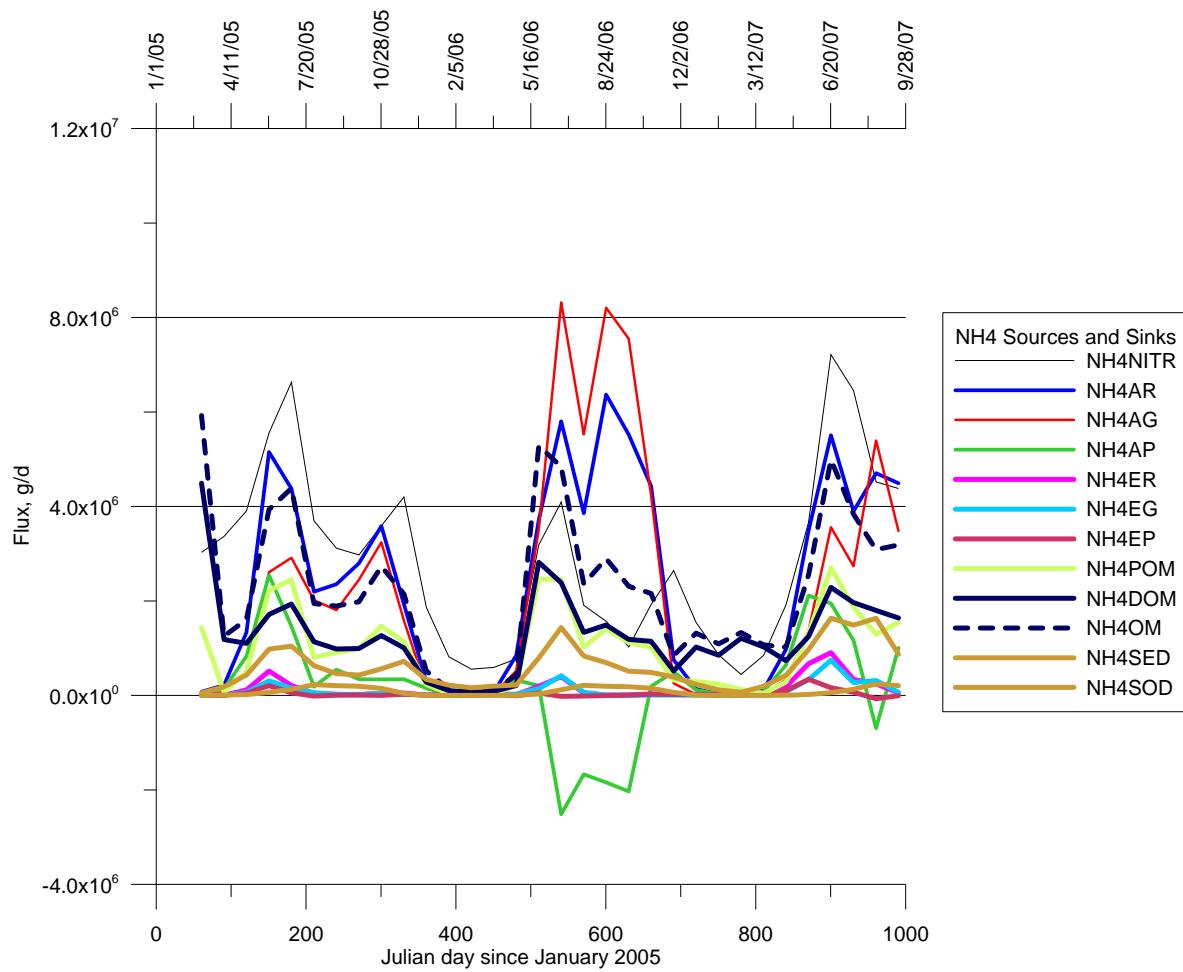


Figure 80. Sources and sinks of ammonia predicted by the model during calibration period.

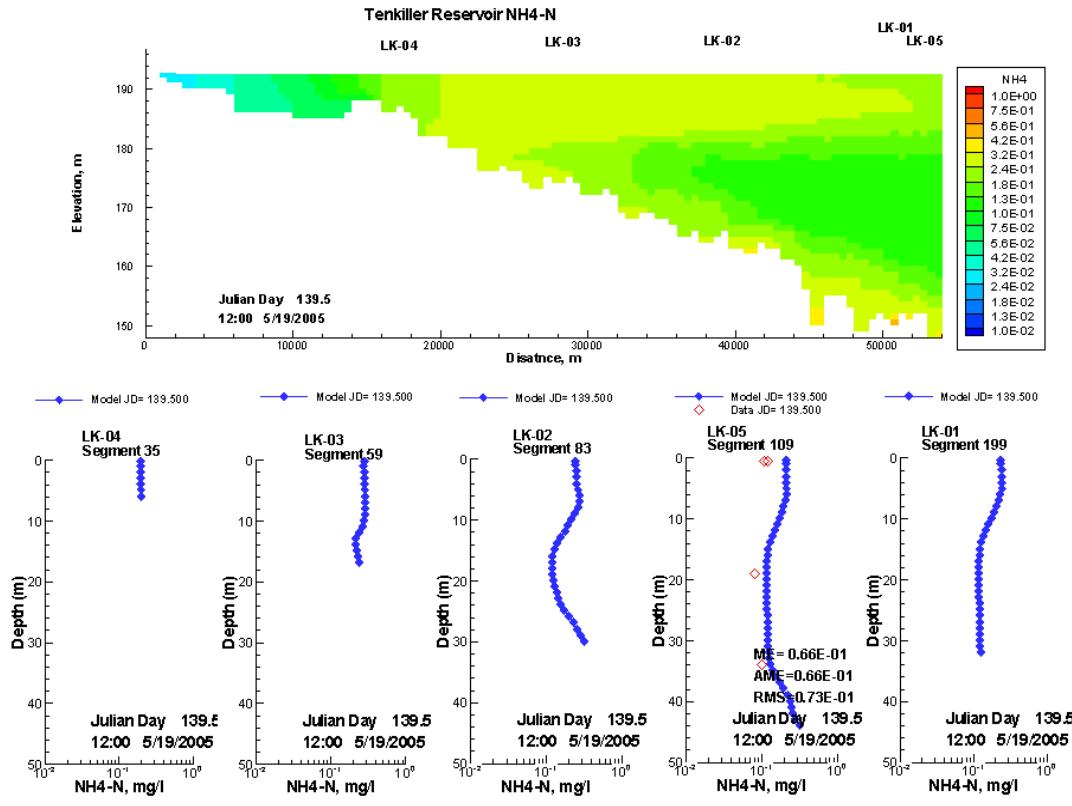


Figure 81. NH₄-N concentrations predicted by the model compared to field data on 5/19/2005.

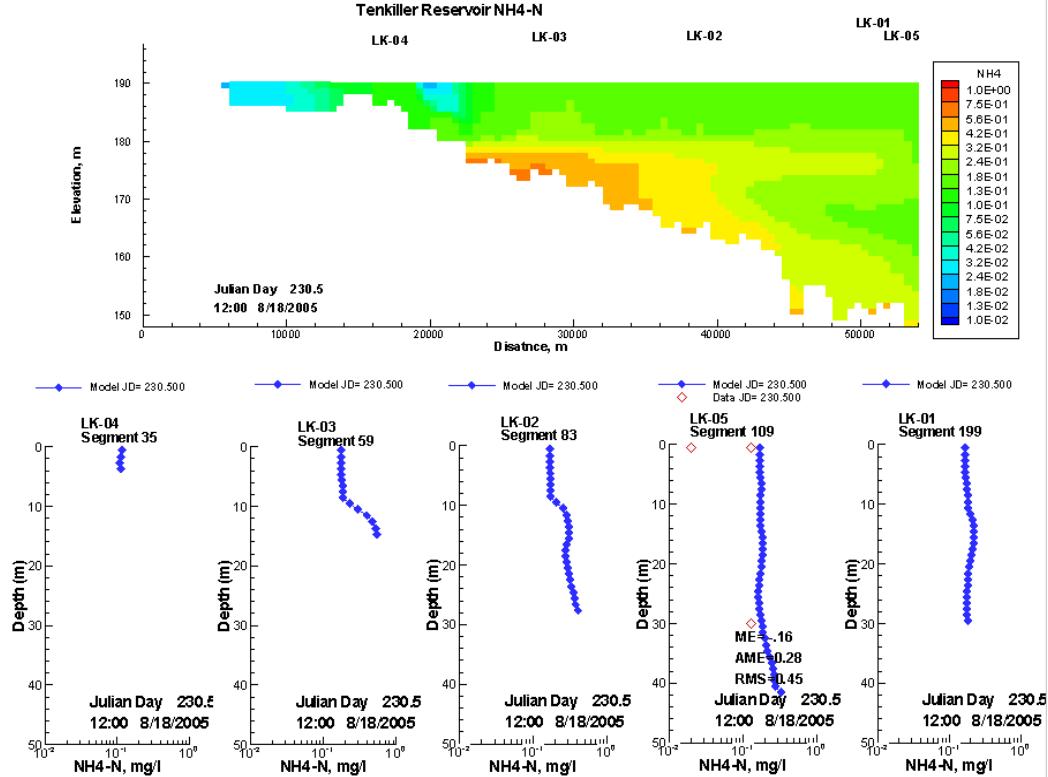


Figure 82. NH₄-N concentrations predicted by the model compared to field data on 8/18/2005.

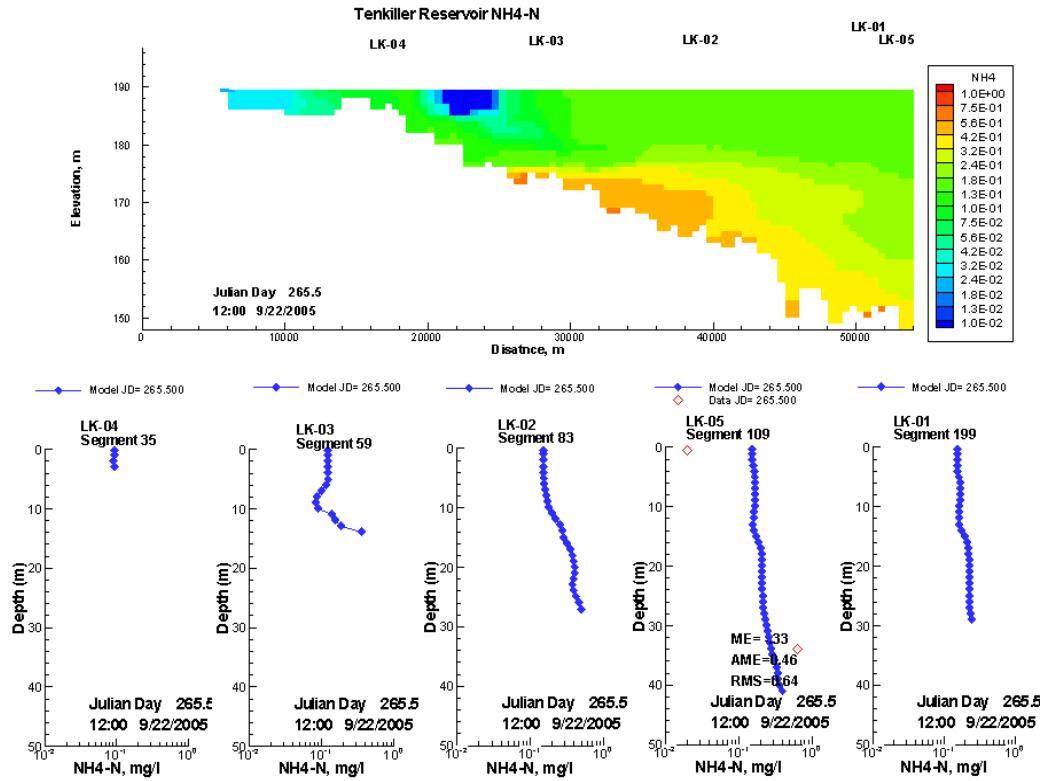


Figure 83. NH₄-N concentrations predicted by the model compared to field data on 9/22/2005.

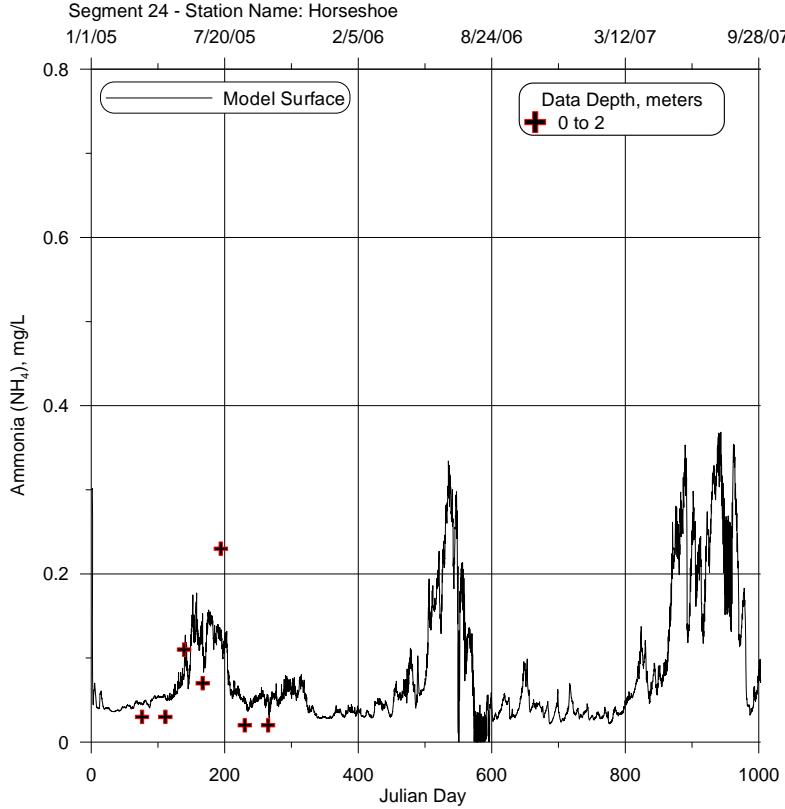


Figure 84. Ammonia as nitrogen model vs. data comparison - segment 24 during calibration period.

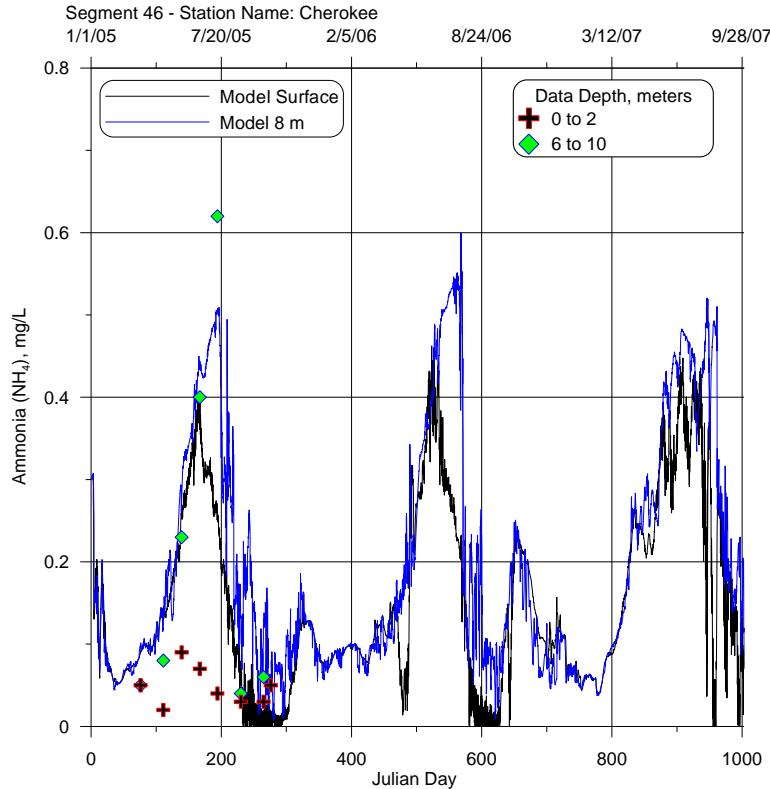


Figure 85. Ammonia as nitrogen model vs. data comparison - segment 46 during calibration period.

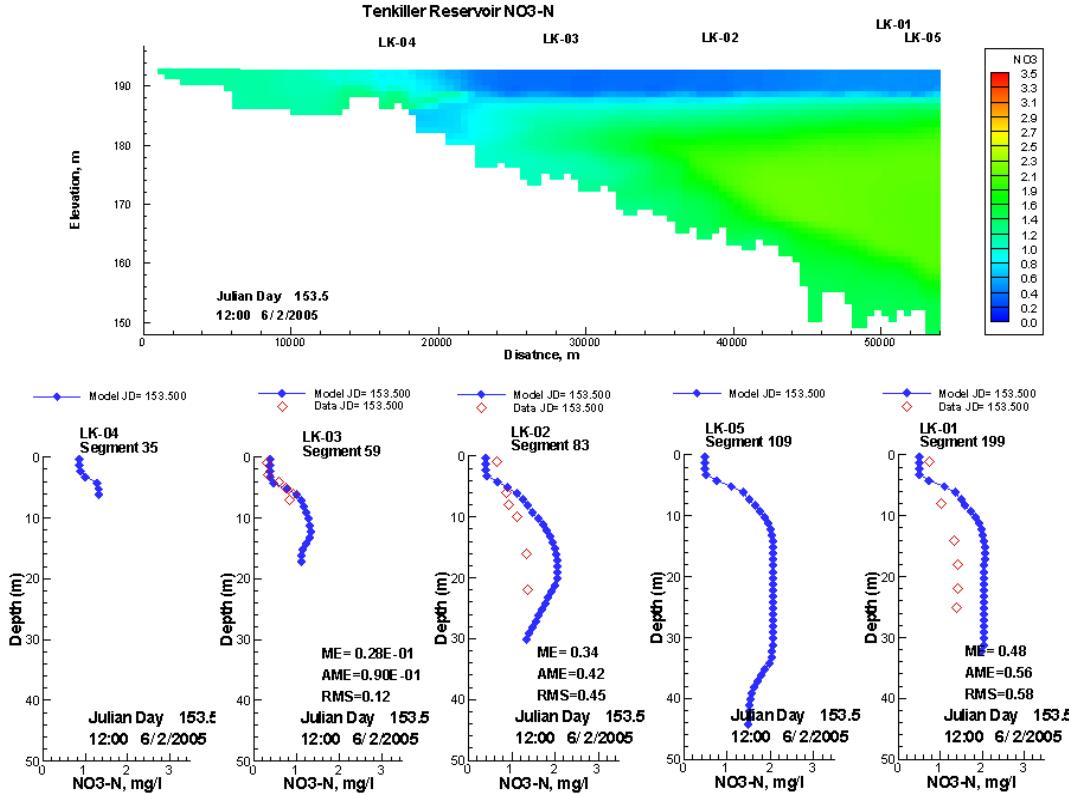


Figure 86. NO₃-N concentrations predicted by the model compared to field data on 6/2/2005.

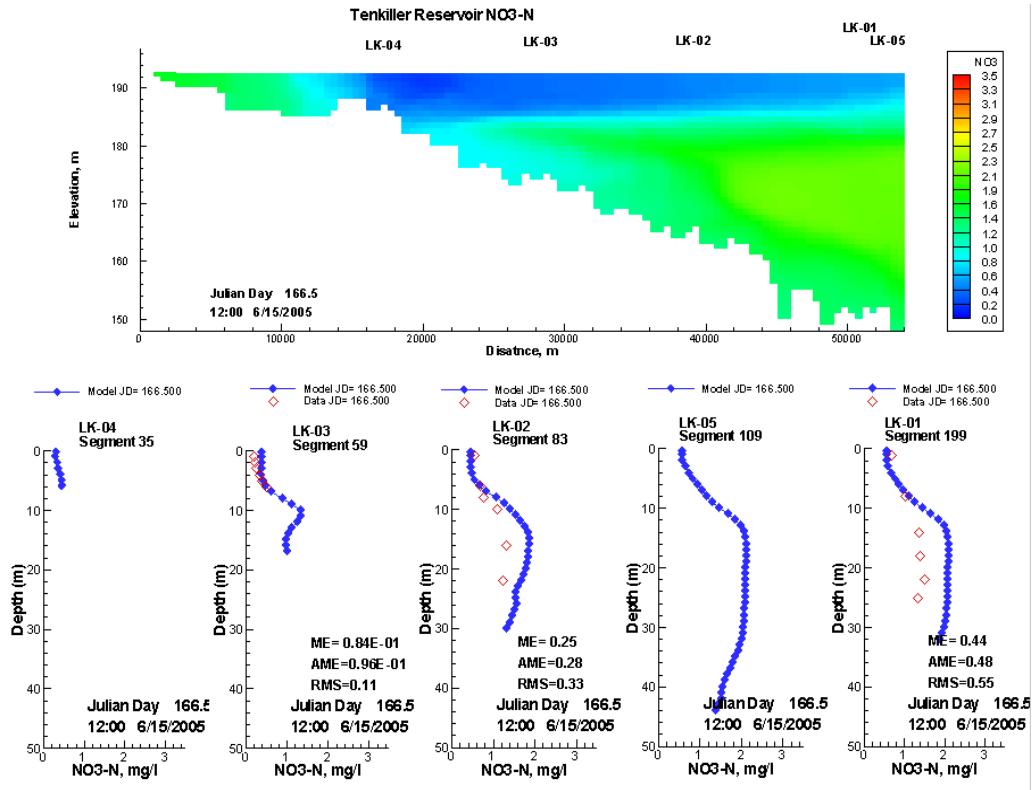


Figure 87. NO₃-N concentrations predicted by the model compared to field data on 6/15/2005.

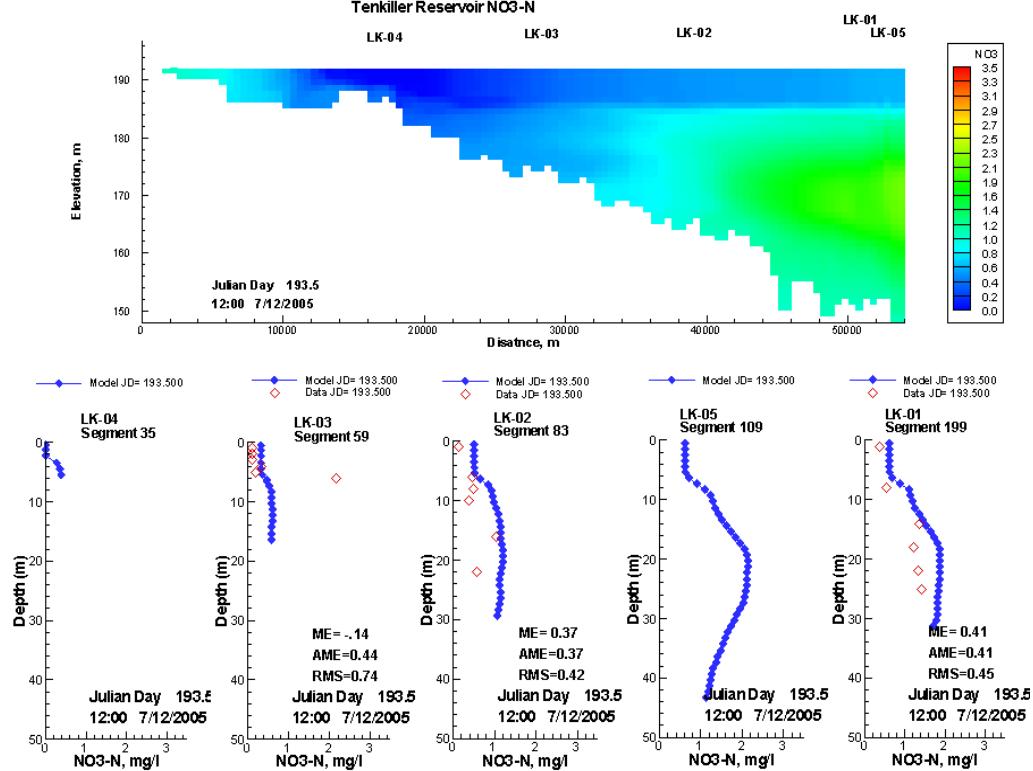


Figure 88. NO₃-N concentrations predicted by the model compared to field data on 7/12/2005.

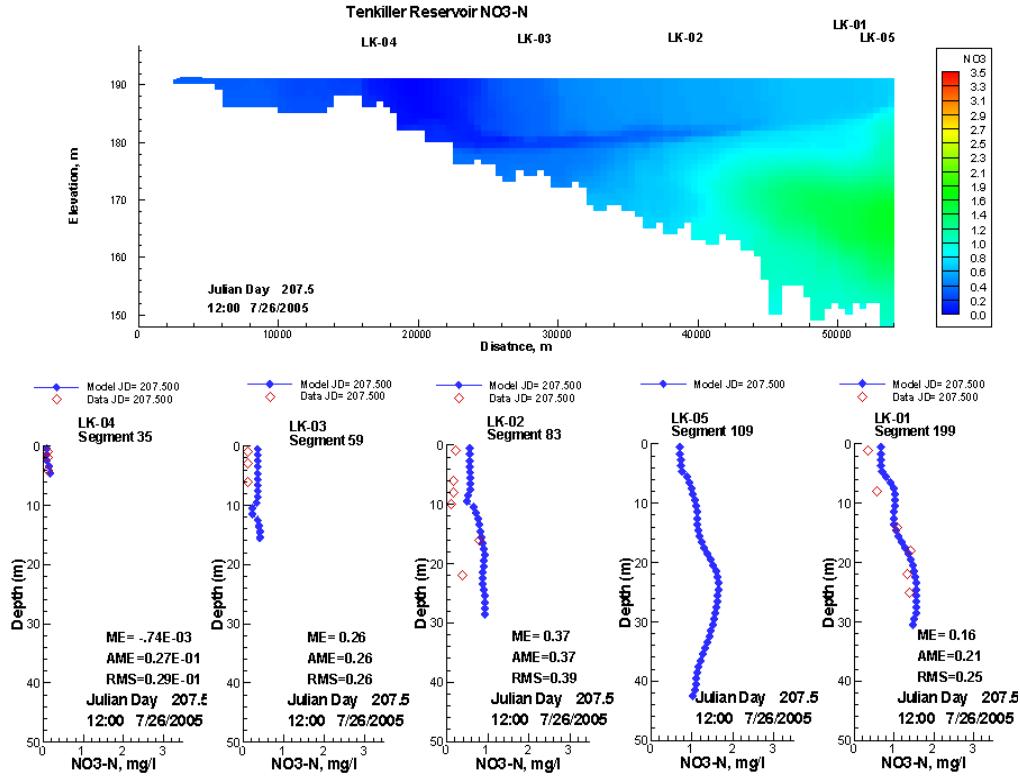


Figure 89. NO₃-N concentrations predicted by the model compared to field data on 7/26/2005.

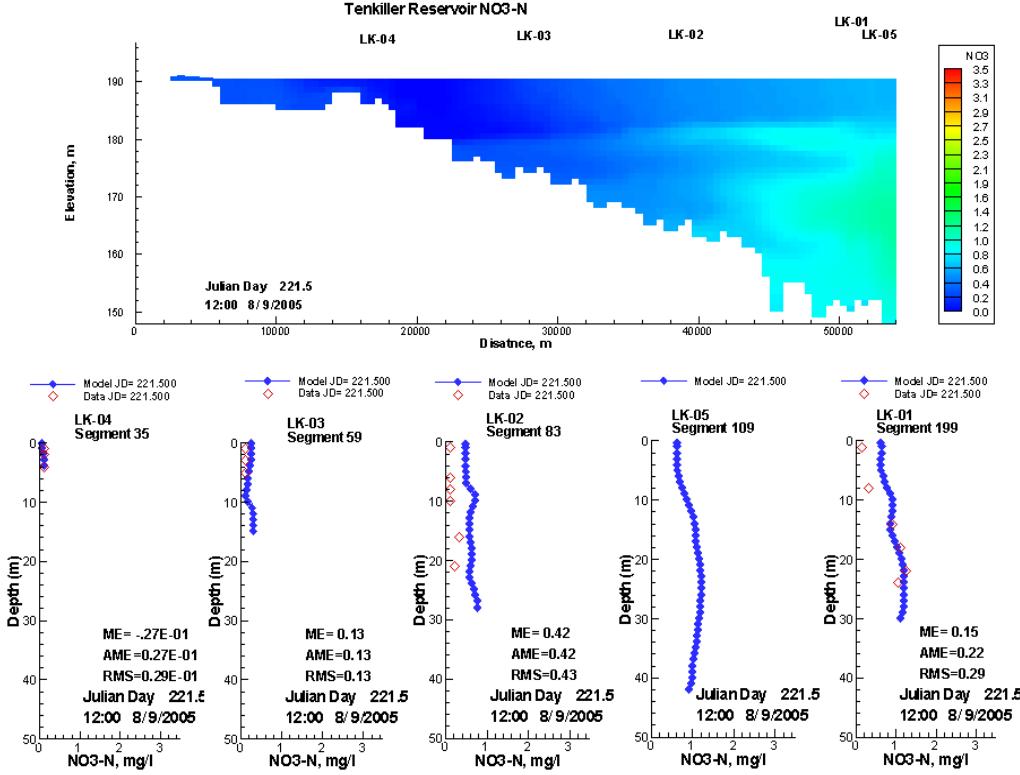


Figure 90. NO₃-N concentrations predicted by the model compared to field data on 8/9/2005.

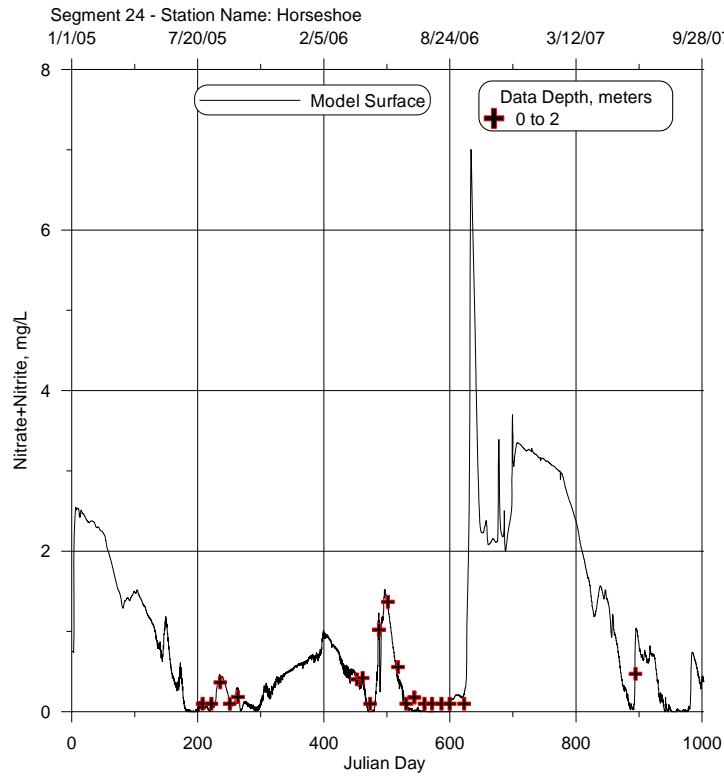


Figure 91. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 24 during calibration period.

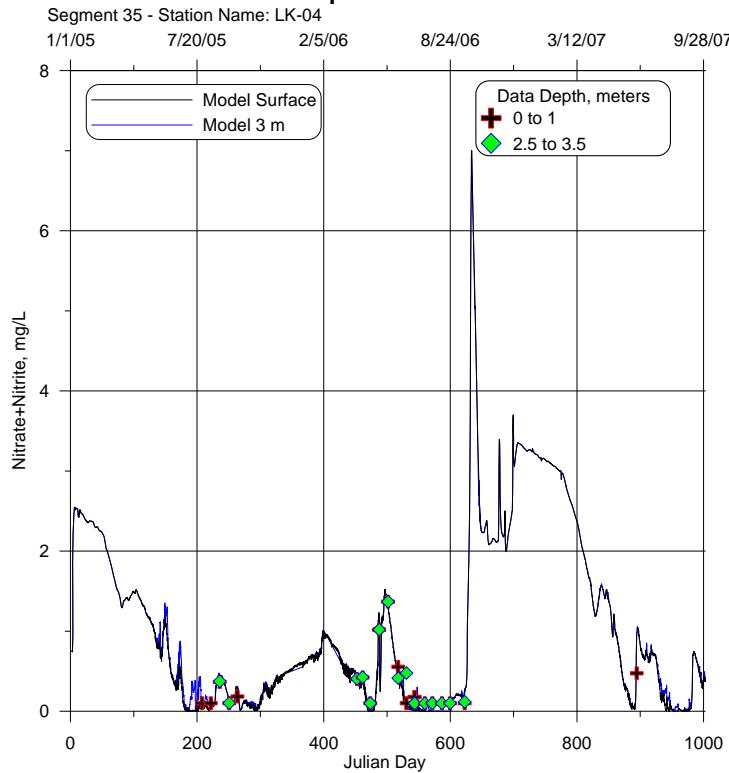


Figure 92. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 35 during calibration period.

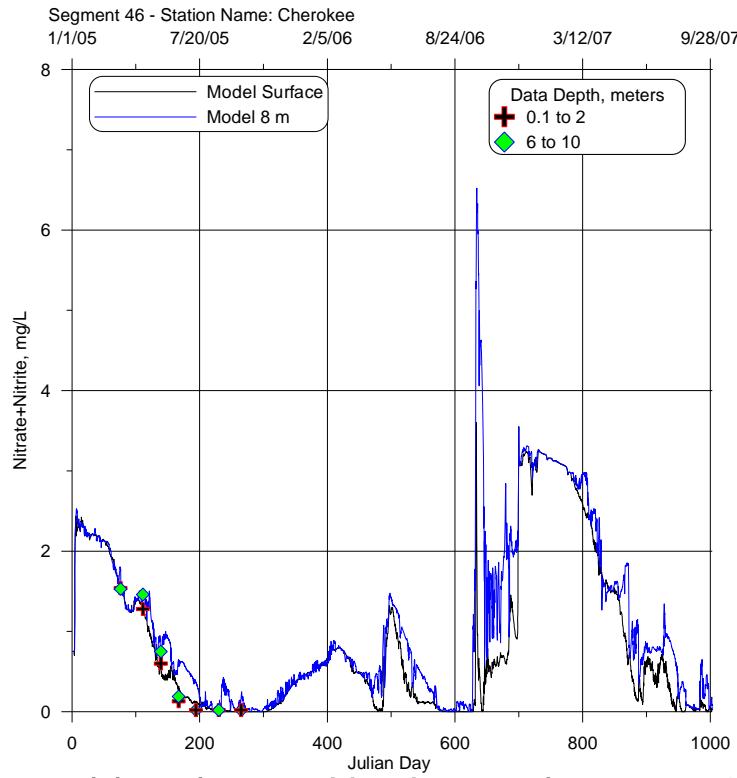


Figure 93. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 46 during calibration period.

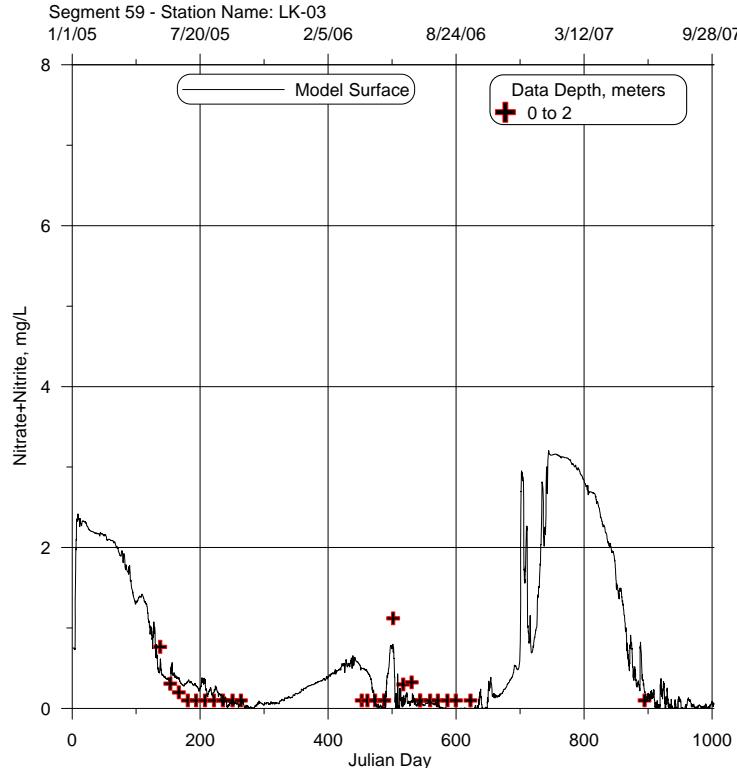


Figure 94. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 59 during calibration period.

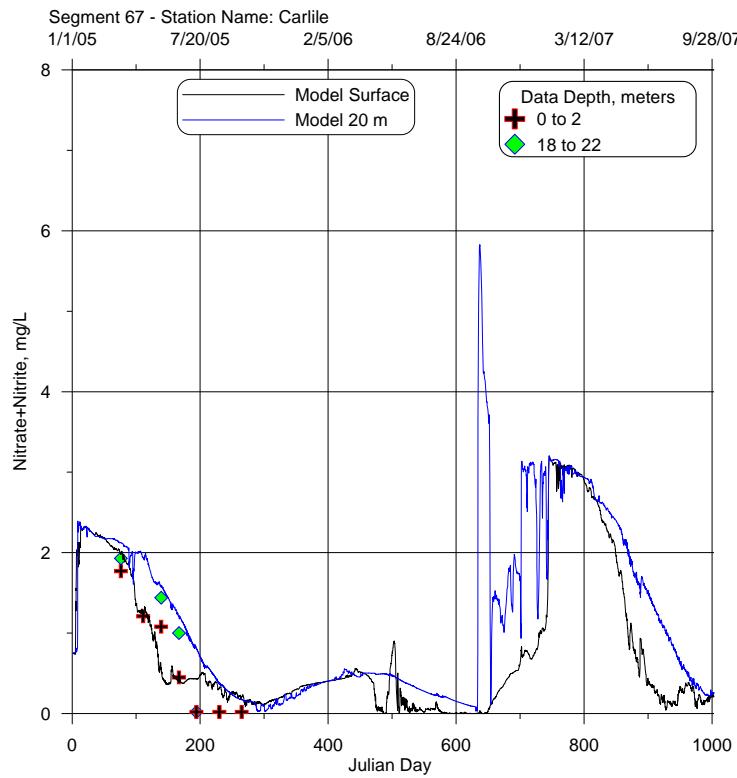


Figure 95. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 67 during calibration period.

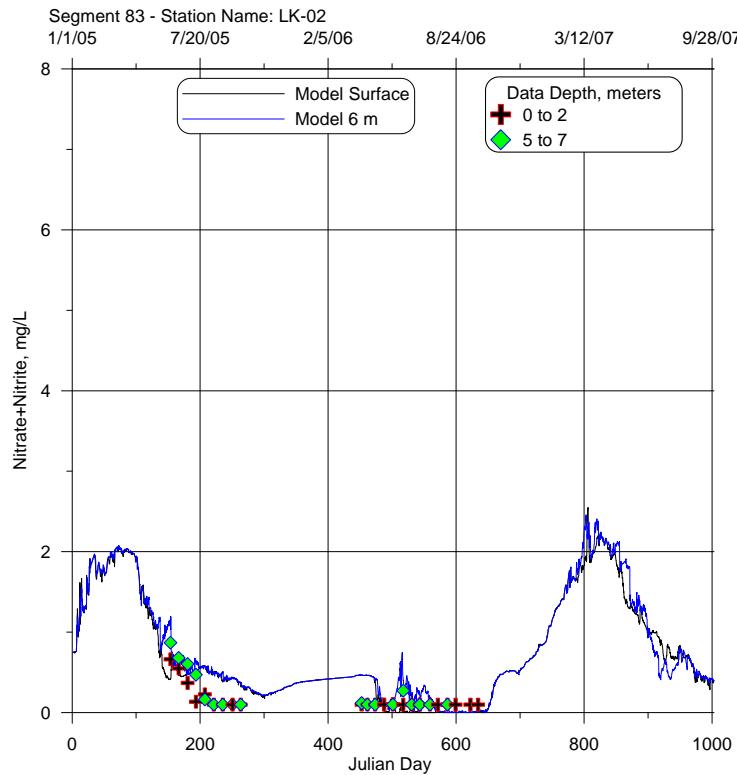


Figure 96. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 83 during calibration period.

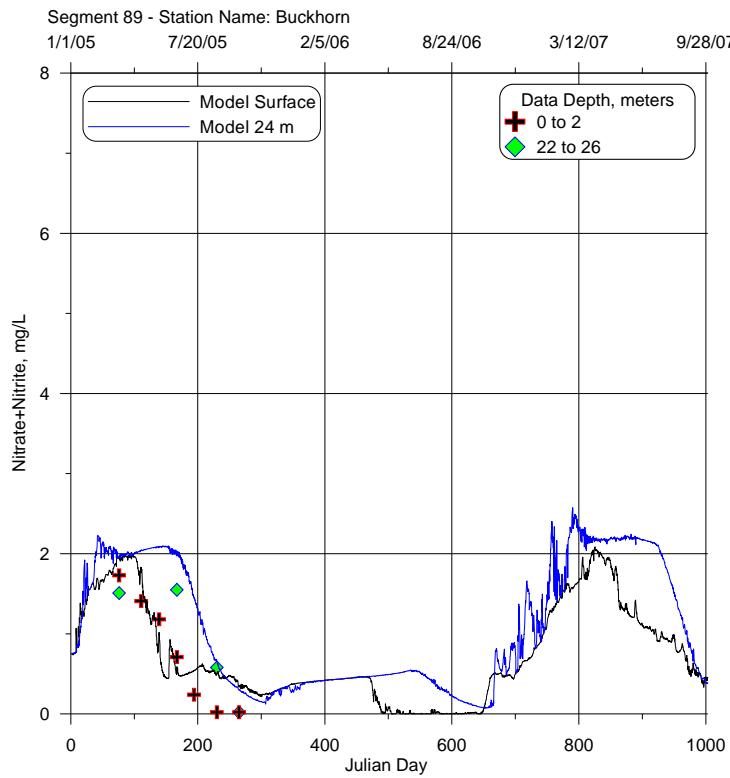


Figure 97. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 89 during calibration period.

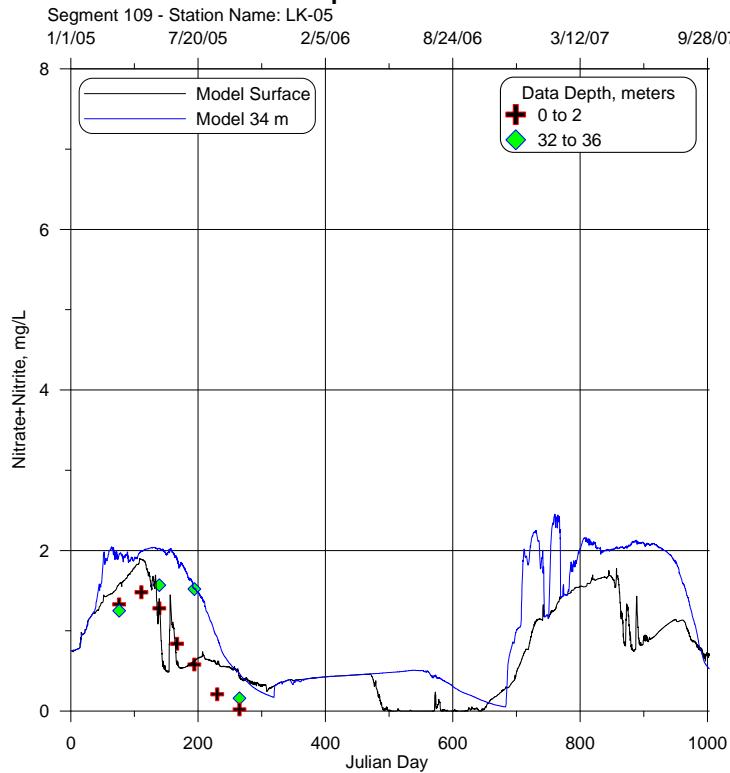


Figure 98. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 109 during calibration period.

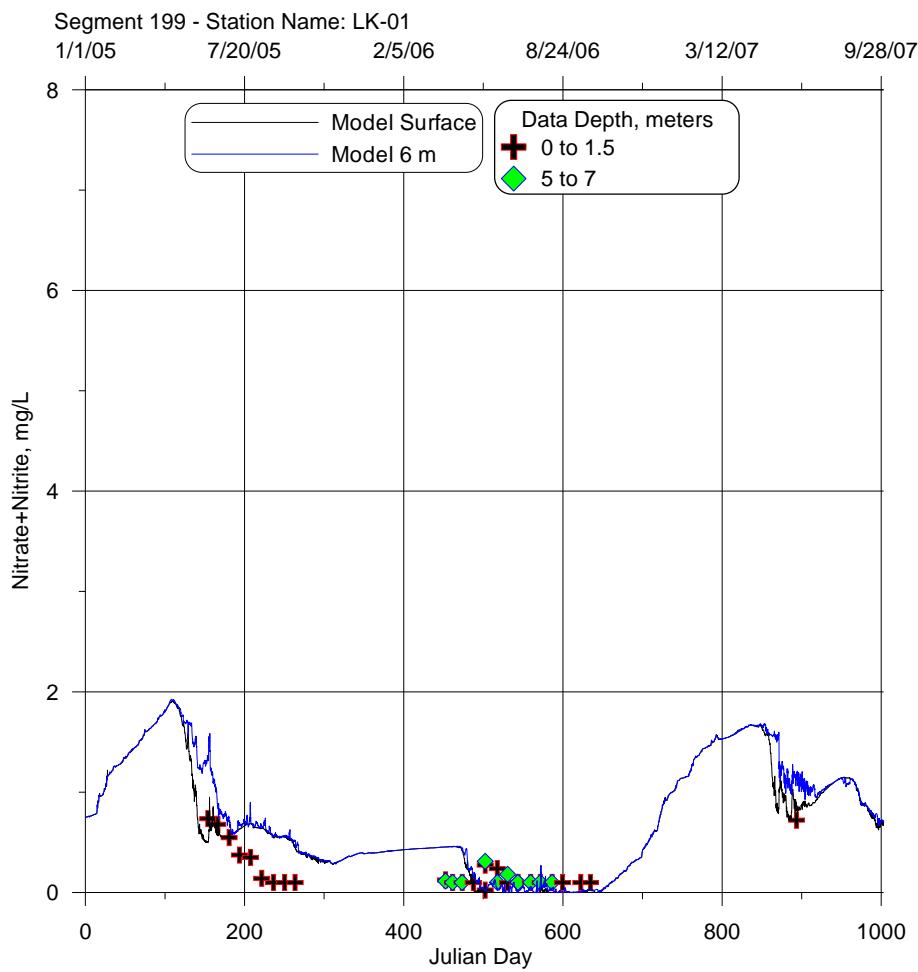


Figure 99. Total nitrate + nitrite as nitrogen model vs. data comparison - segment 199 during calibration period.

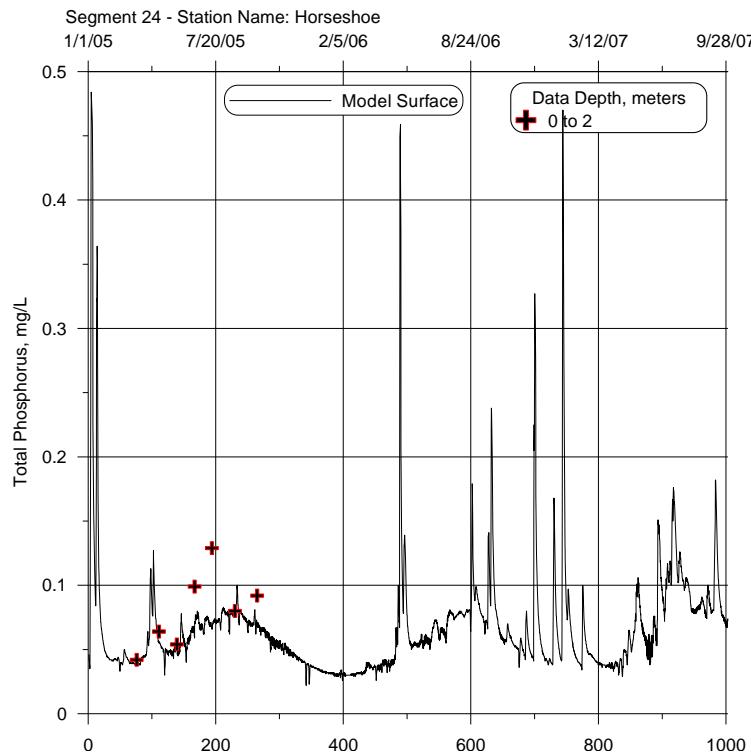


Figure 100. Total phosphorus model vs. data comparison – segment 24 during calibration period.

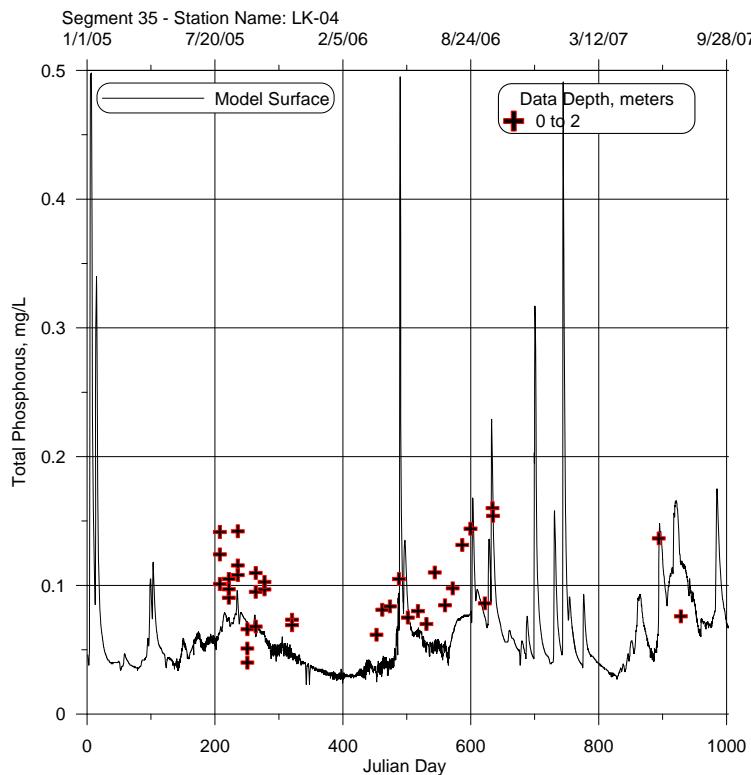


Figure 101. Total phosphorus model vs. data comparison – segment 35 during calibration period.

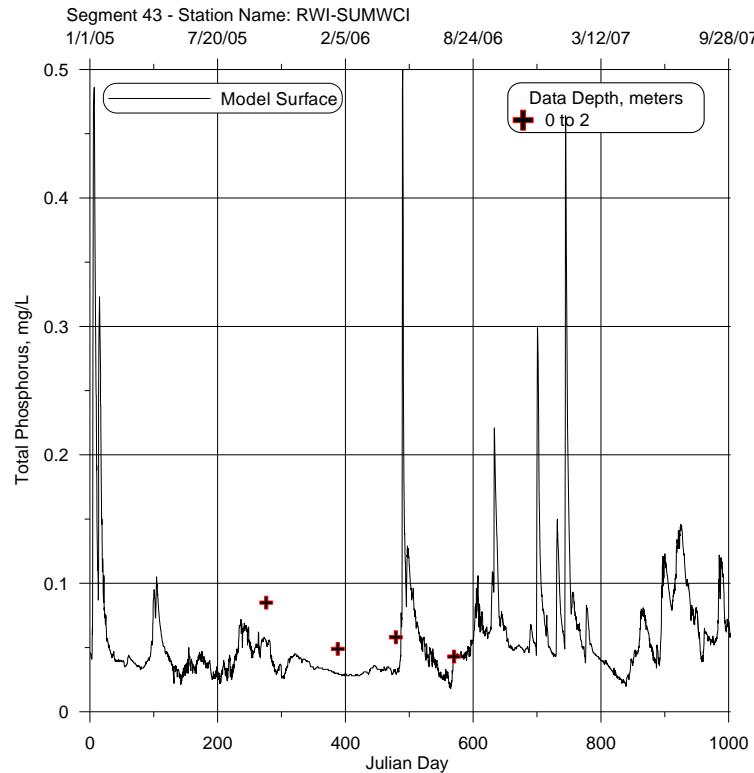


Figure 102. Total phosphorus model vs. data comparison – segment 43 during calibration period.

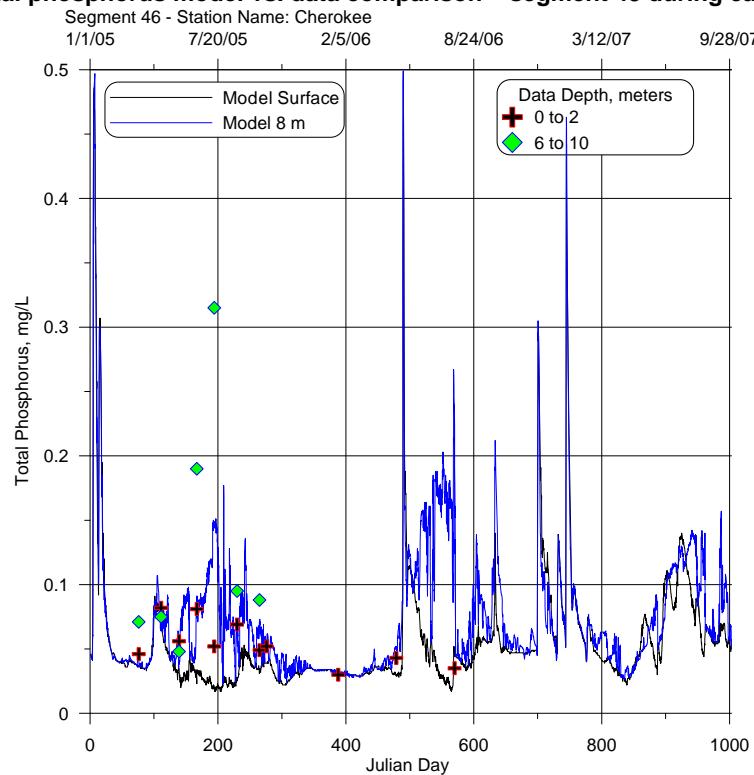


Figure 103. Total phosphorus model vs. data comparison – segment 46 during calibration period.

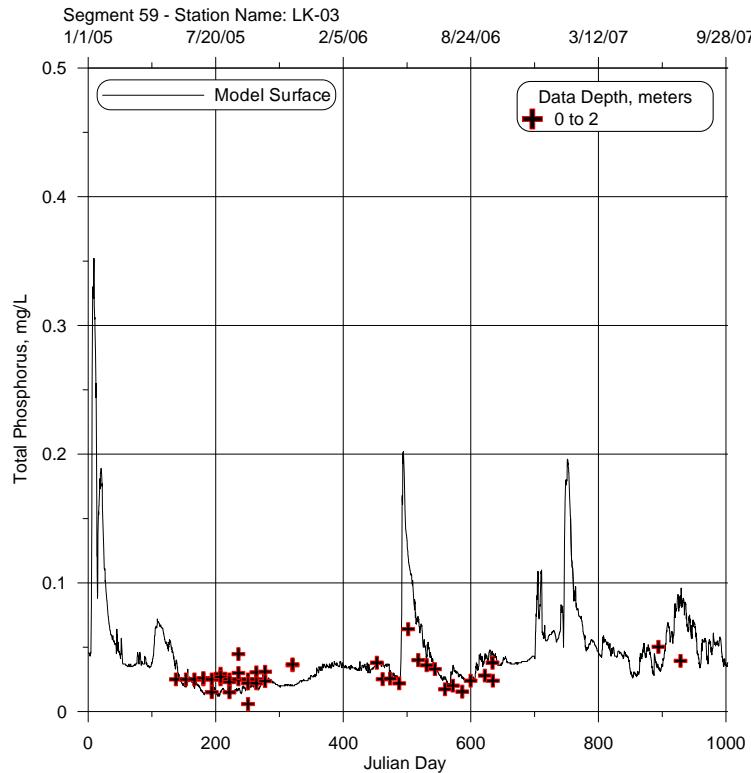


Figure 104. Total phosphorus model vs. data comparison – segment 59 during calibration period.

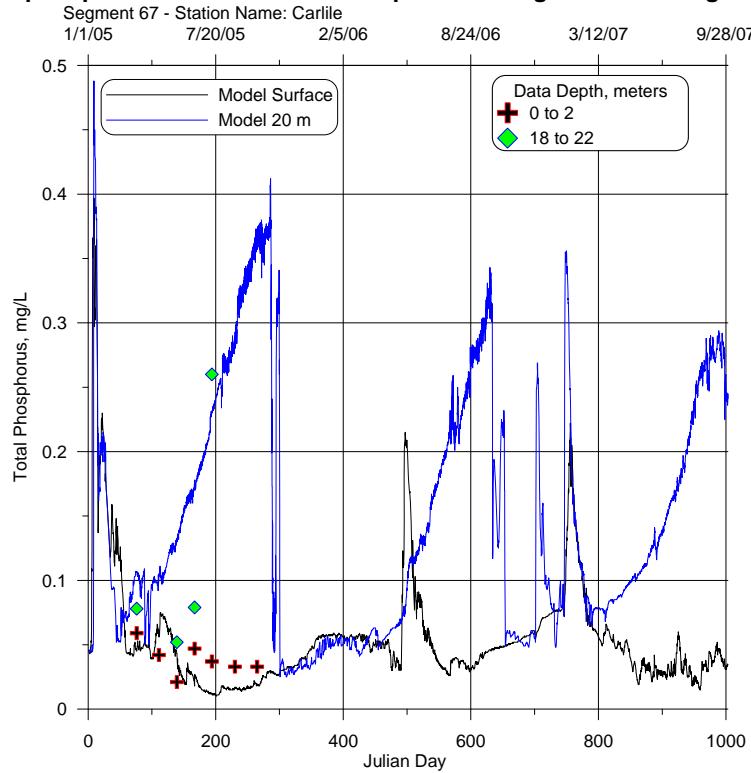
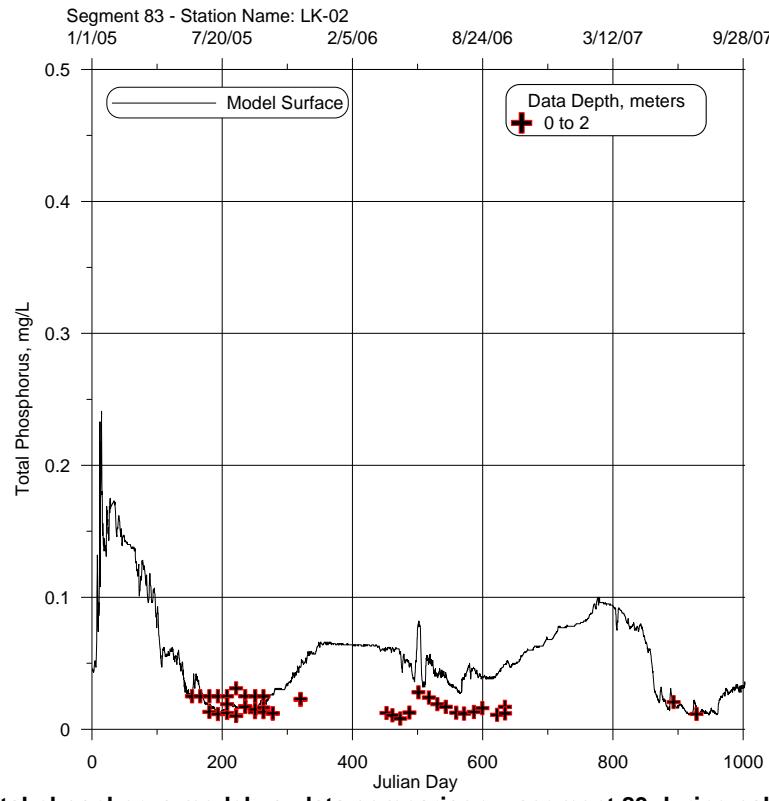
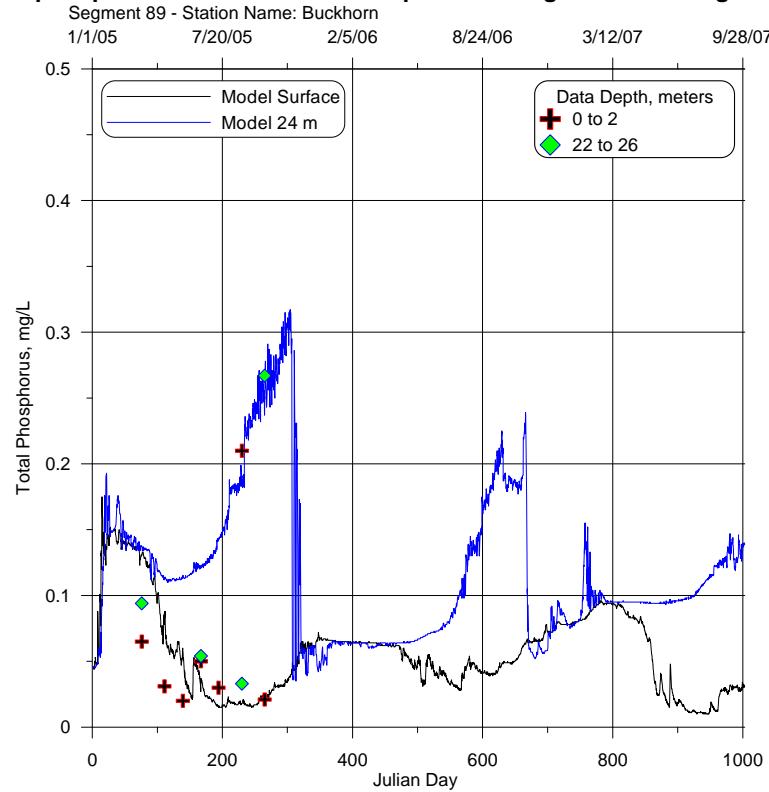


Figure 105. Total phosphorus model vs. data comparison – segment 67 during calibration period.

**Figure 106. Total phosphorus model vs. data comparison – segment 83 during calibration period.****Figure 107. Total phosphorus model vs. data comparison – segment 89 during calibration period.**

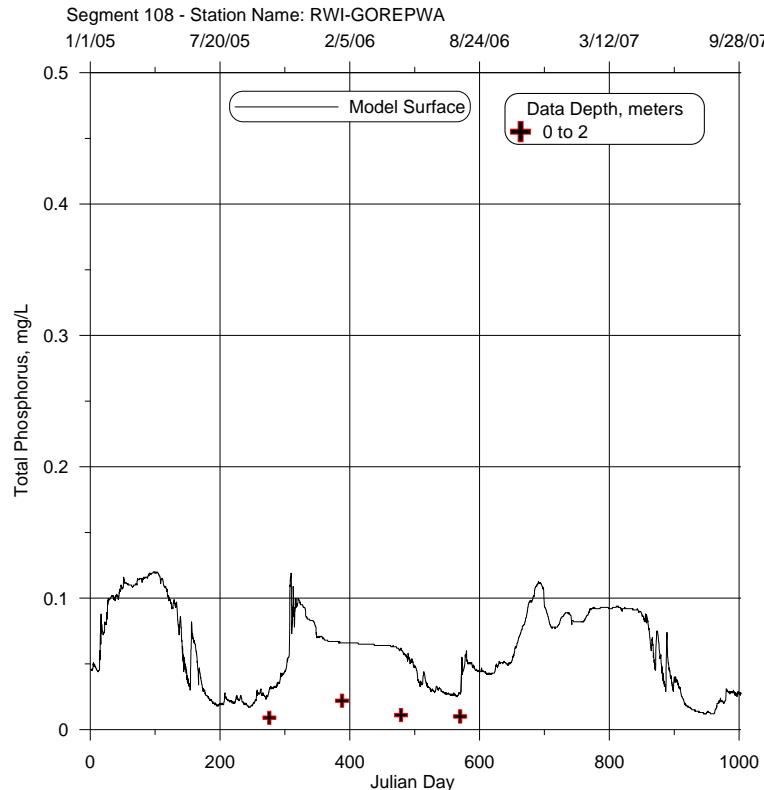


Figure 108. Total phosphorus model vs. data comparison – segment 108 during calibration period.

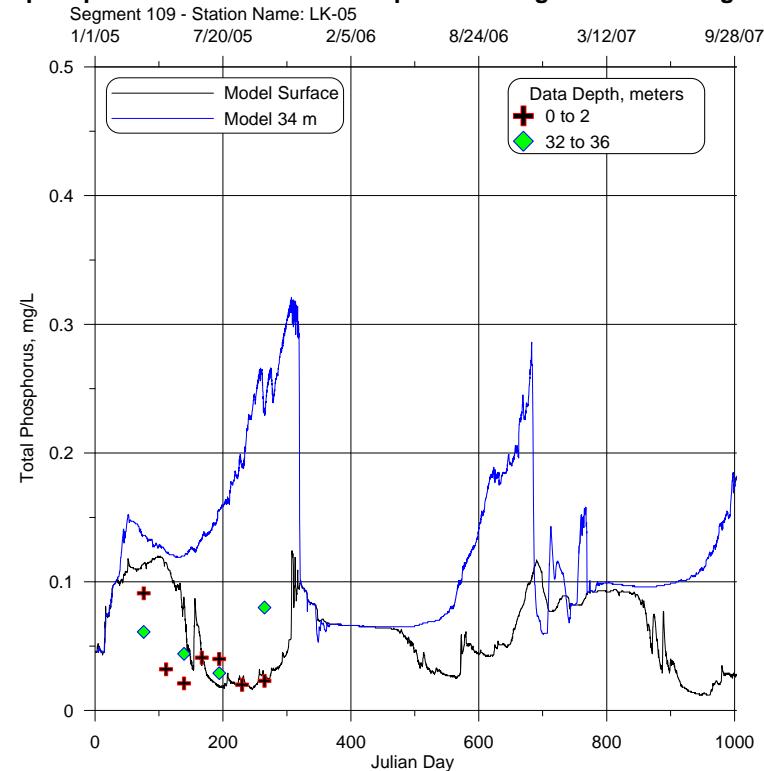


Figure 109. Total phosphorus model vs. data comparison – segment 109 during calibration period.

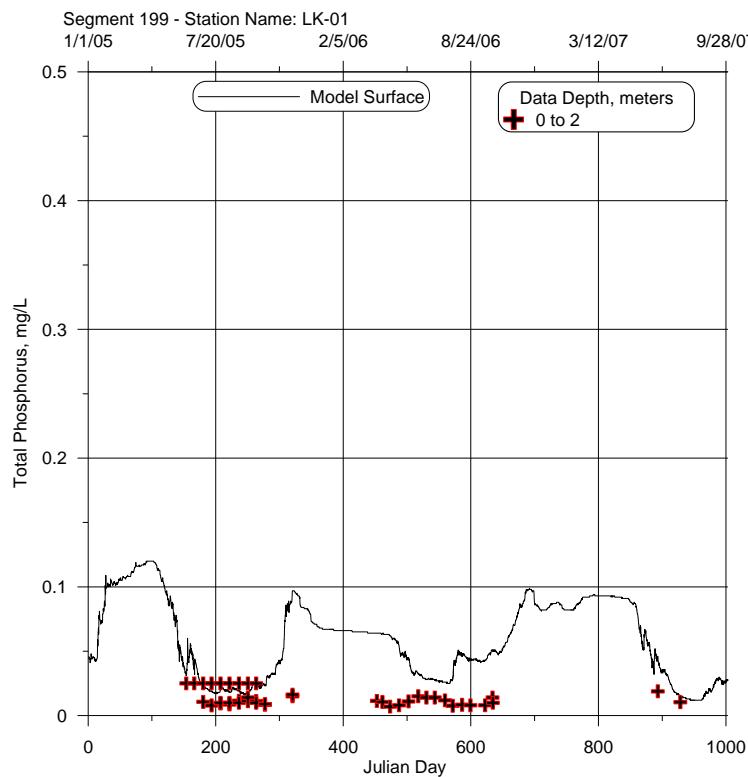


Figure 110. Total phosphorus model vs. data comparison – segment 199 during calibration period.

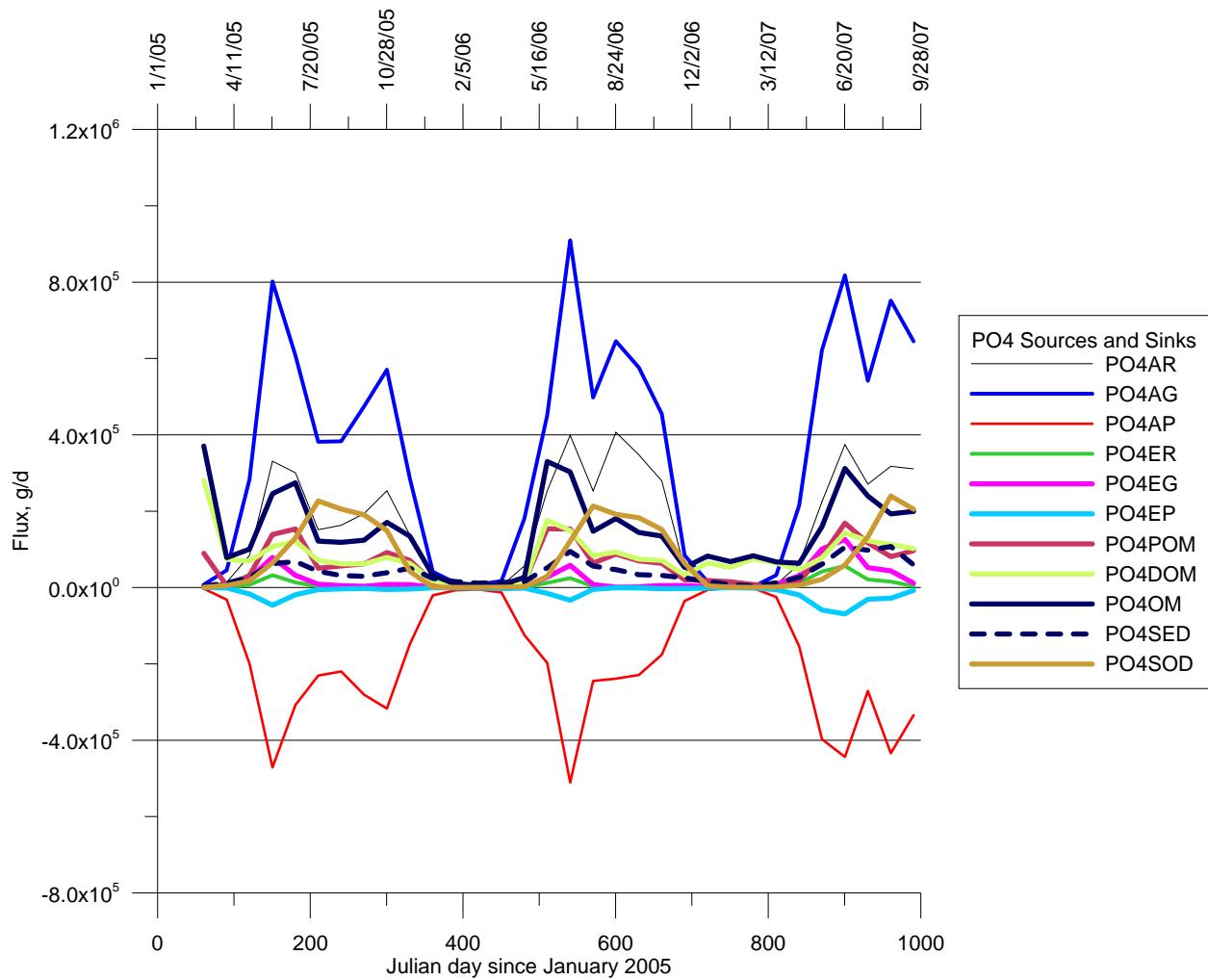


Figure 111. Sources and sinks of dissolved PO₄-P predicted by the model during calibration period.

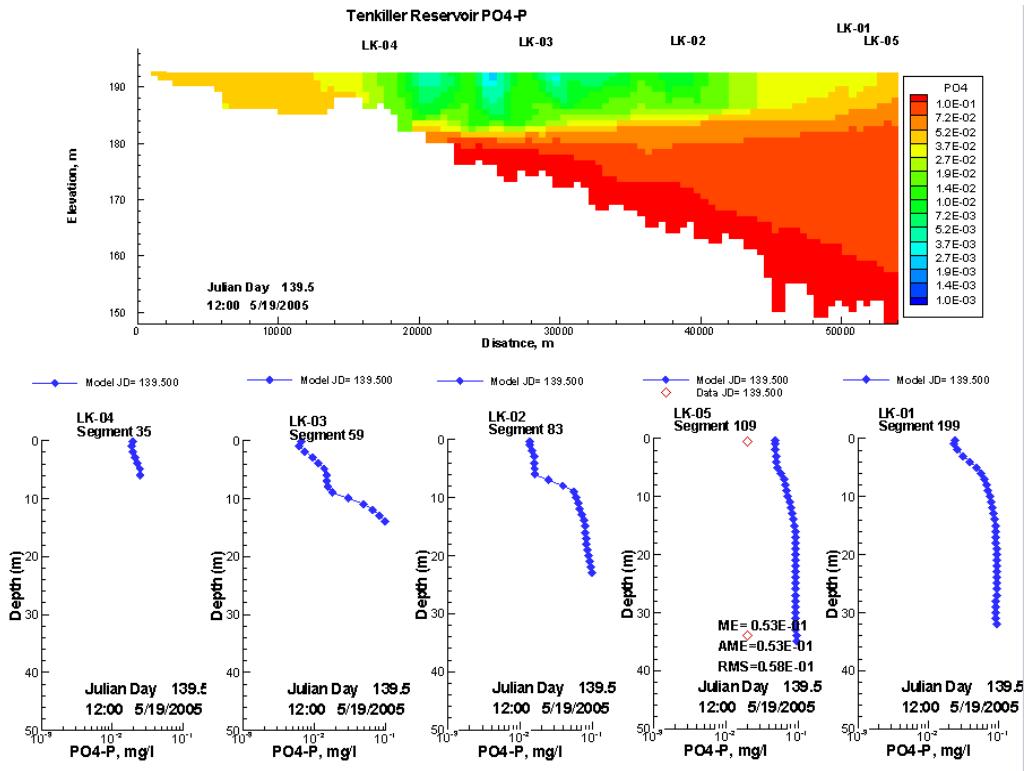


Figure 112. PO₄-P concentrations predicted by the model compared to field data on 5/19/2005.

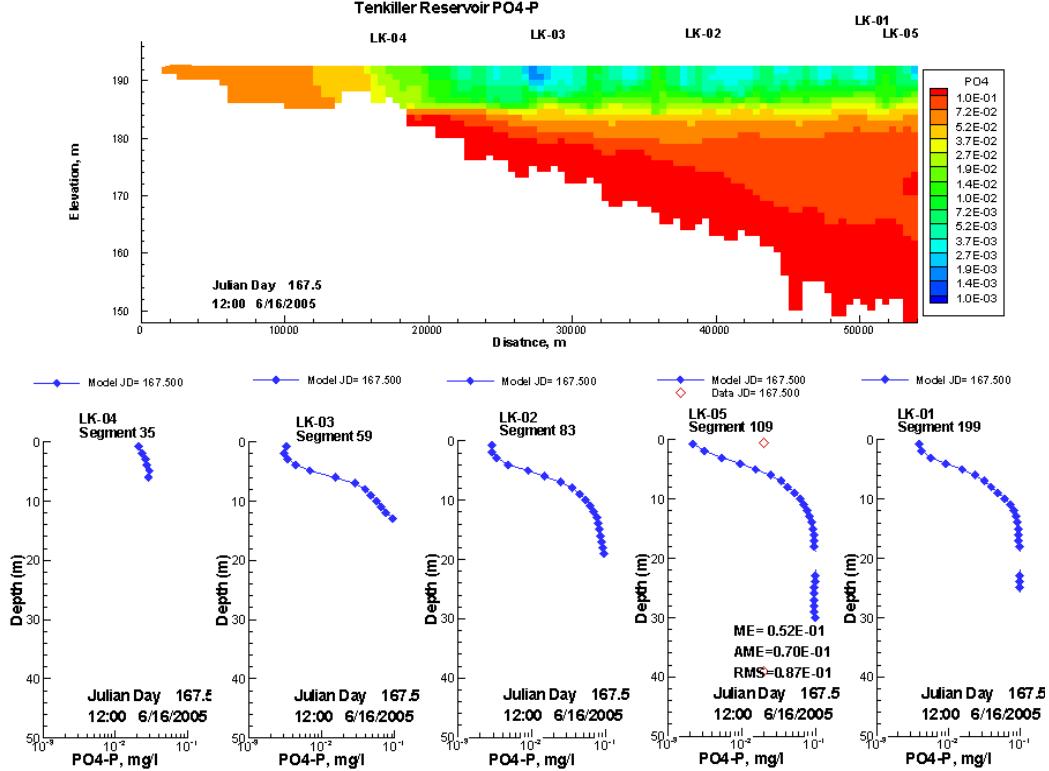


Figure 113. PO₄-P concentrations predicted by the model compared to field data on 6/16/2005.

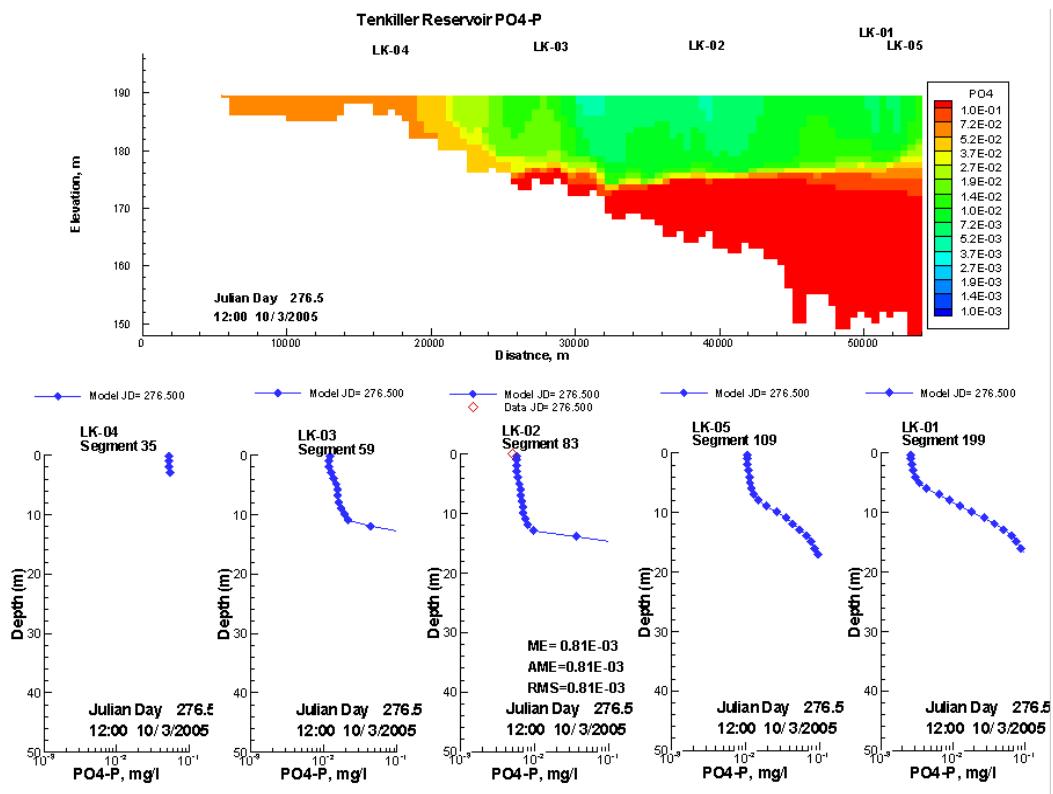


Figure 114. PO₄-P concentrations predicted by the model compared to field data on 10/3/2005.

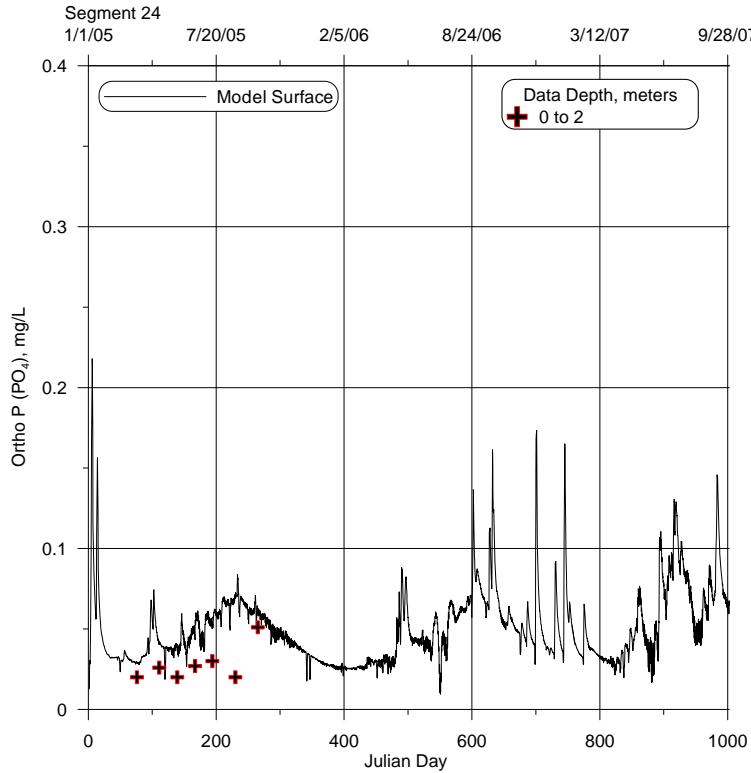


Figure 115. Ortho phosphorus model vs. data comparison – segment 24 during calibration period.

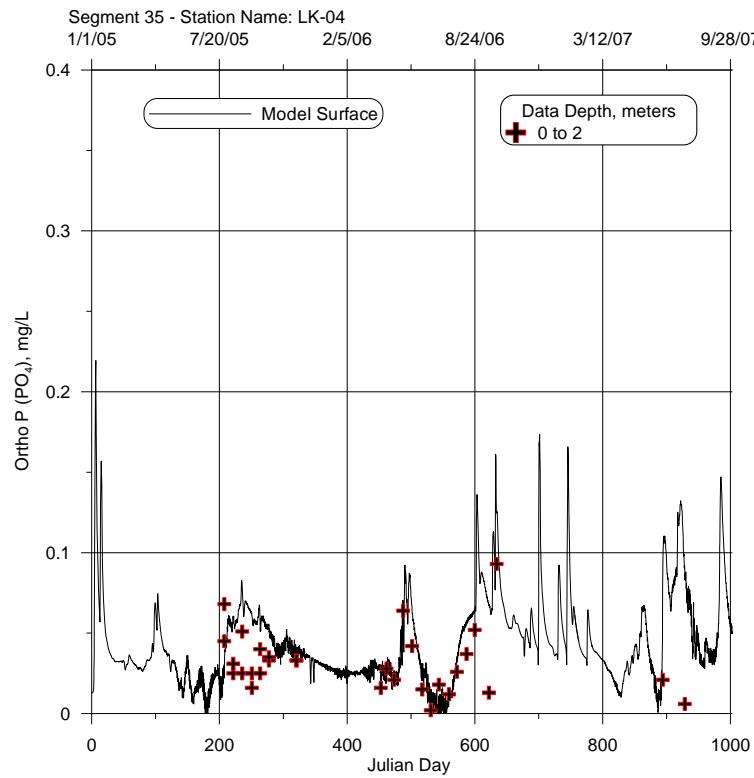


Figure 116. Ortho phosphorus model vs. data comparison – segment 35 during calibration period.

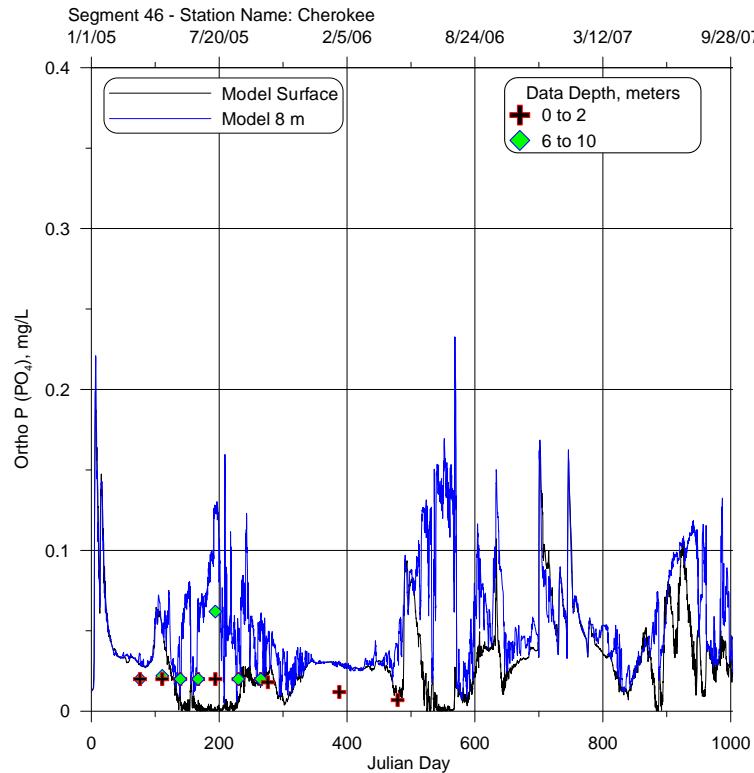


Figure 117. Ortho phosphorus model vs. data comparison – segment 46 during calibration period.

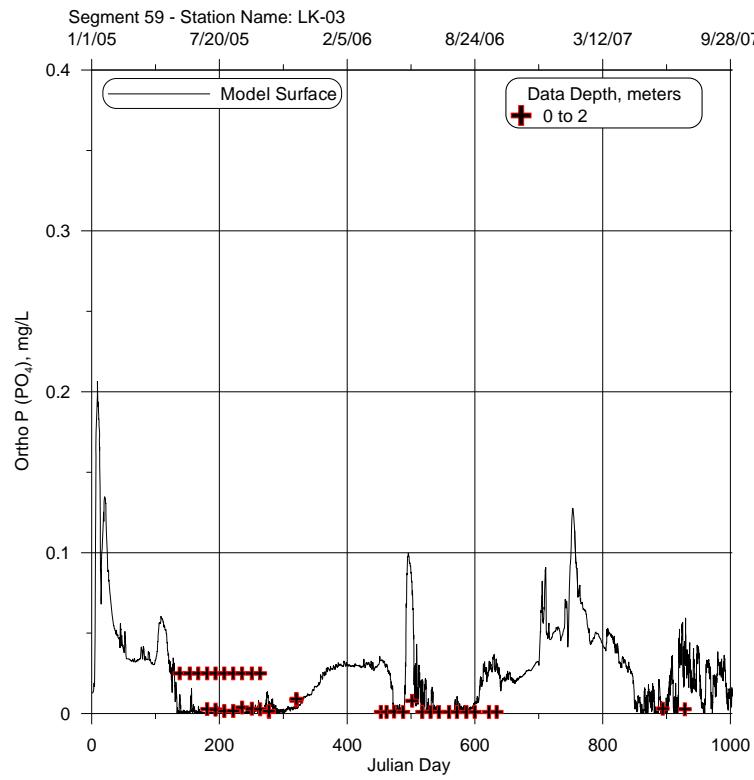


Figure 118. Ortho phosphorus model vs. data comparison – segment 59 during calibration period.

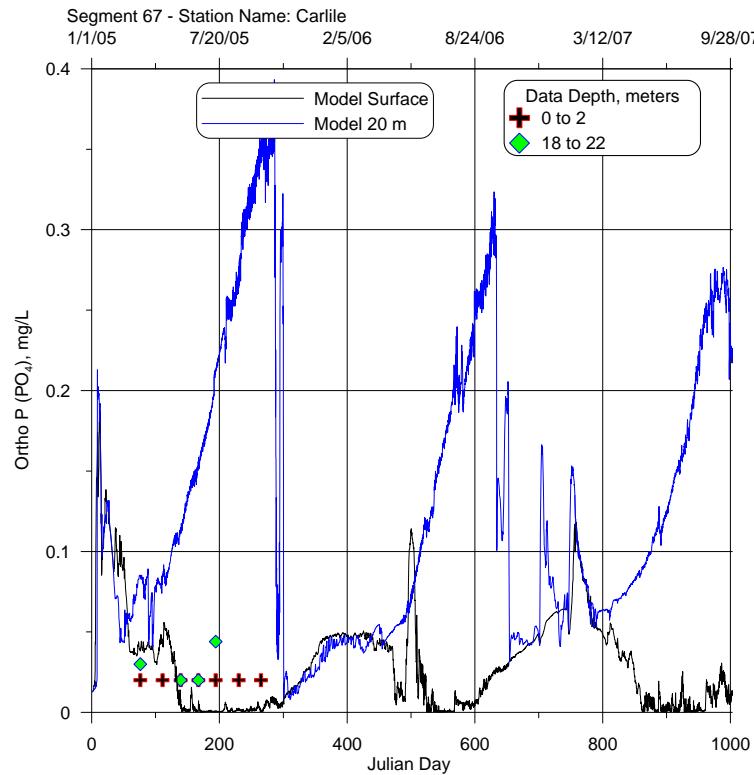


Figure 119. Ortho phosphorus model vs. data comparison – segment 67 during calibration period.

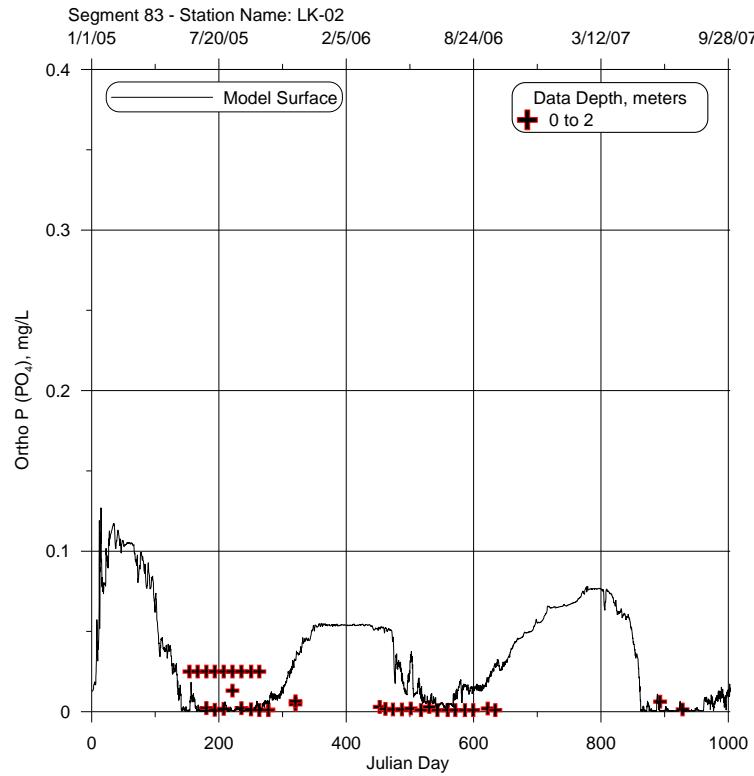


Figure 120. Ortho phosphorus model vs. data comparison – segment 83 during calibration period.

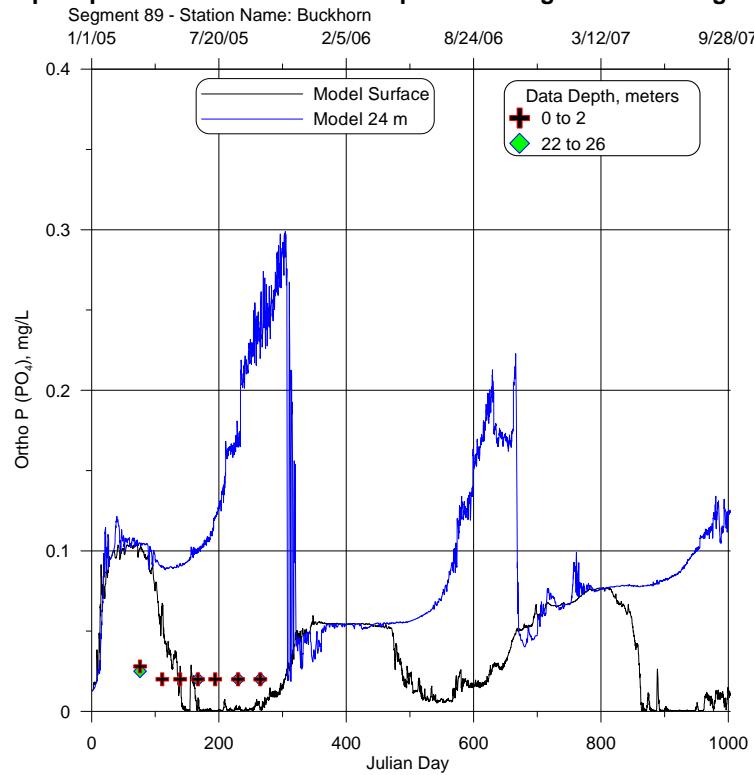


Figure 121. Ortho phosphorus model vs. data comparison – segment 89 during calibration period.

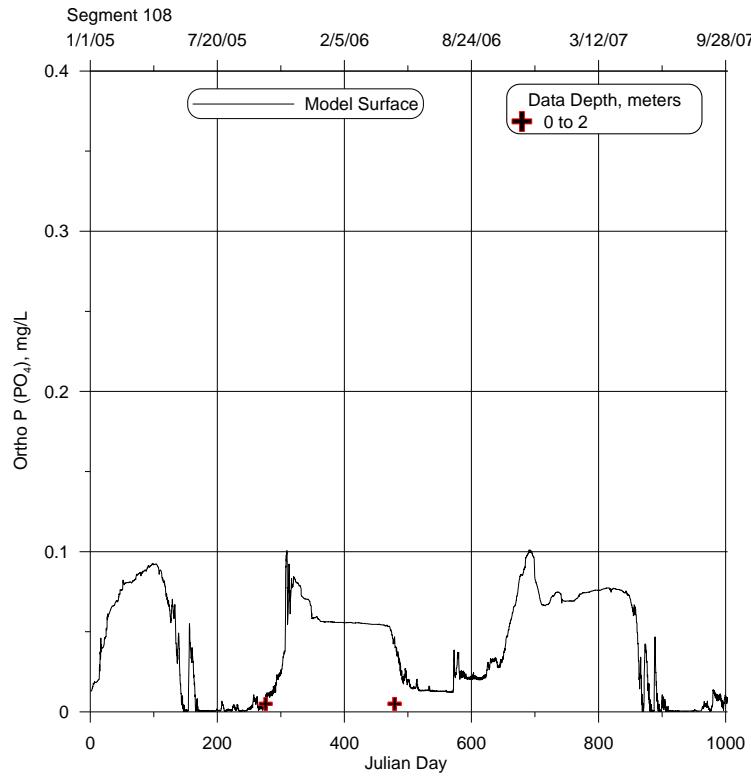


Figure 122. Ortho phosphorus model vs. data comparison – segment 108 during calibration period.

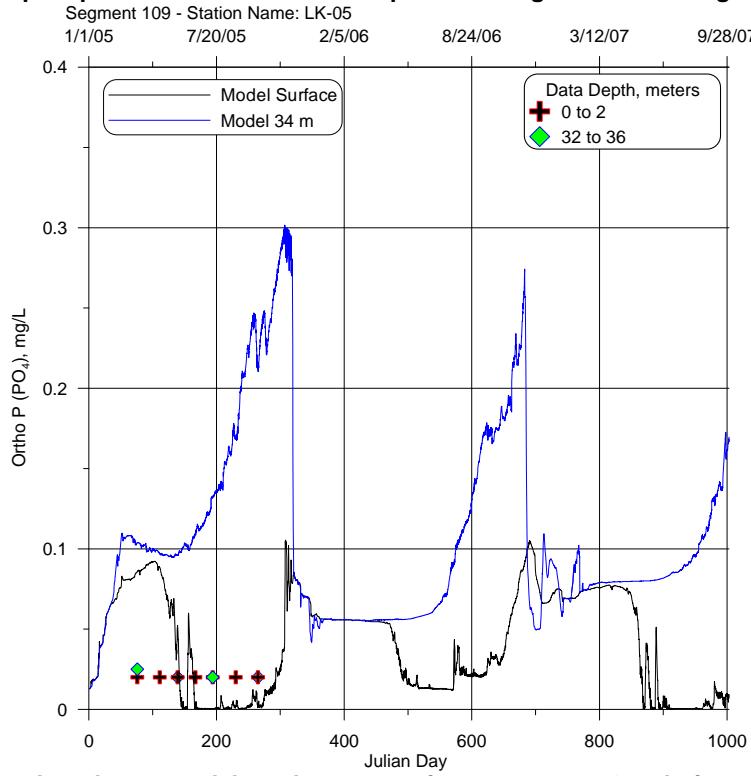


Figure 123. Ortho phosphorus model vs. data comparison – segment 109 during calibration period.

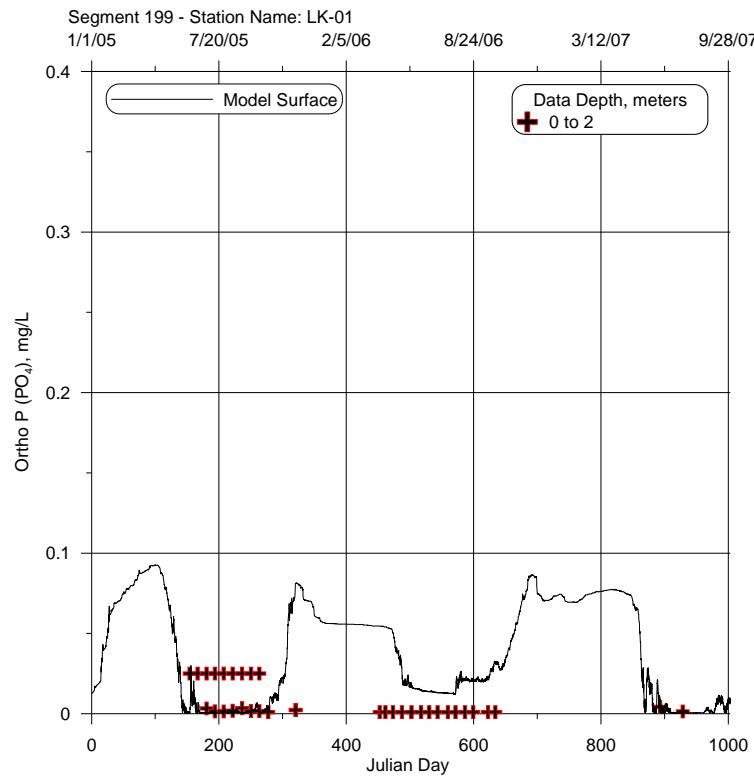


Figure 124. Ortho phosphorus model vs. data comparison – segment 199 during calibration period.

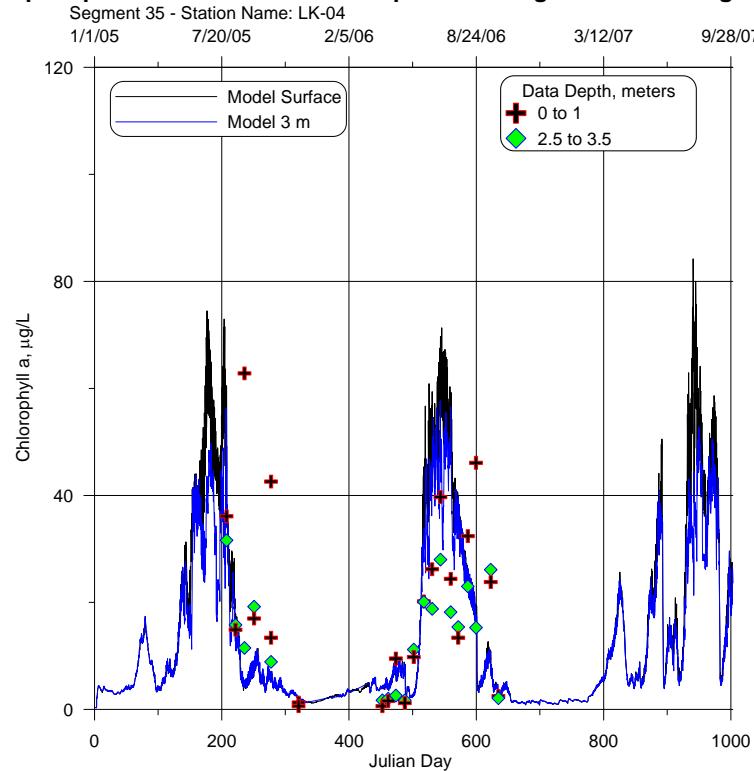


Figure 125. Chlorophyll a model vs. data comparison – segment 35 during calibration period.

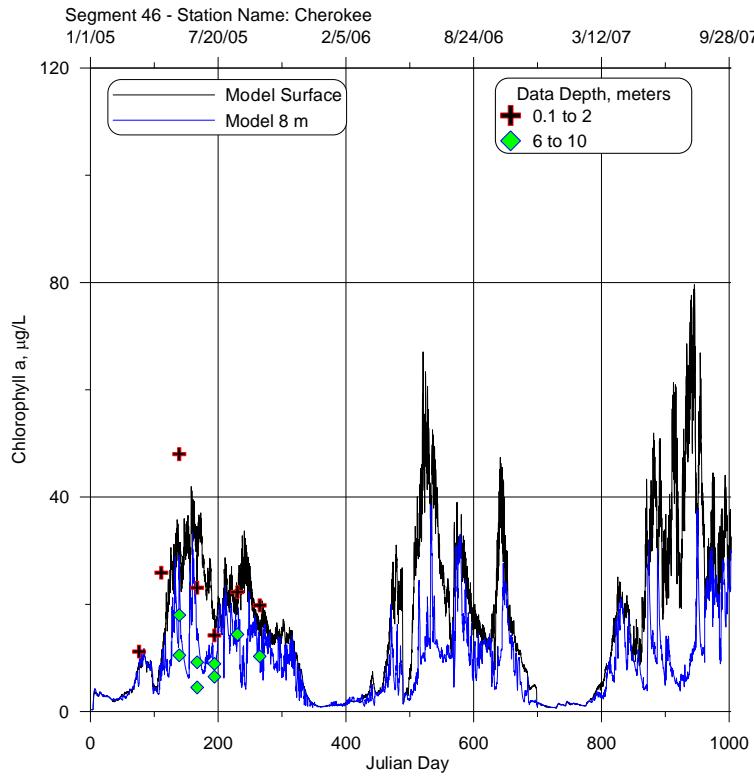


Figure 126. Chlorophyll a model vs. data comparison – segment 46 during calibration period.

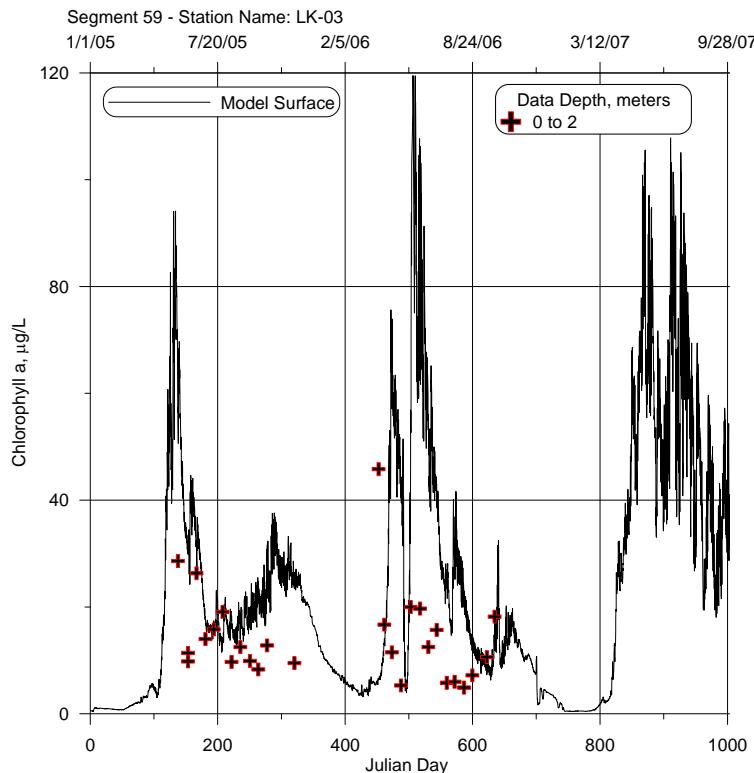


Figure 127. Chlorophyll a model vs. data comparison – segment 59 during calibration period.

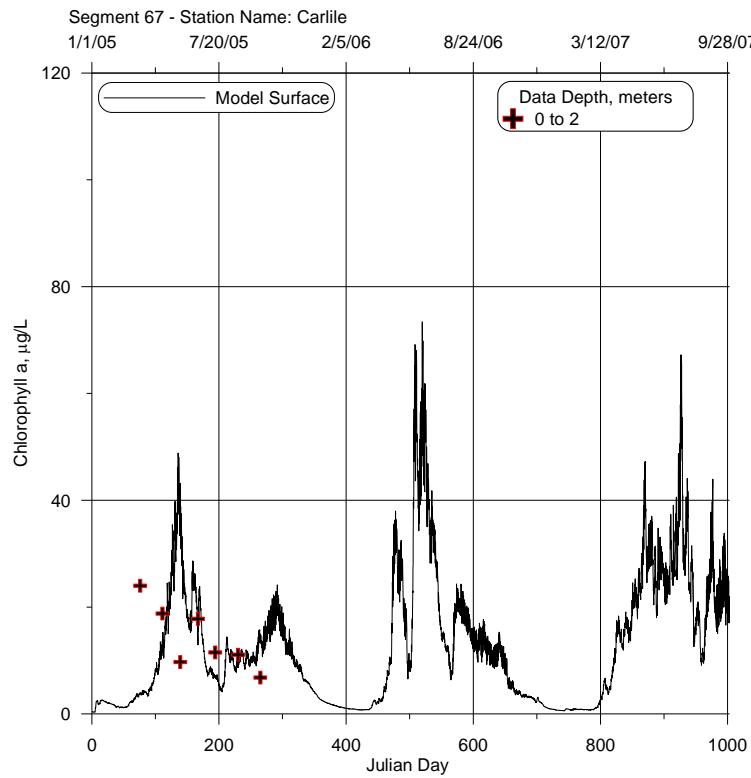


Figure 128. Chlorophyll a model vs. data comparison – segment 67 during calibration period.

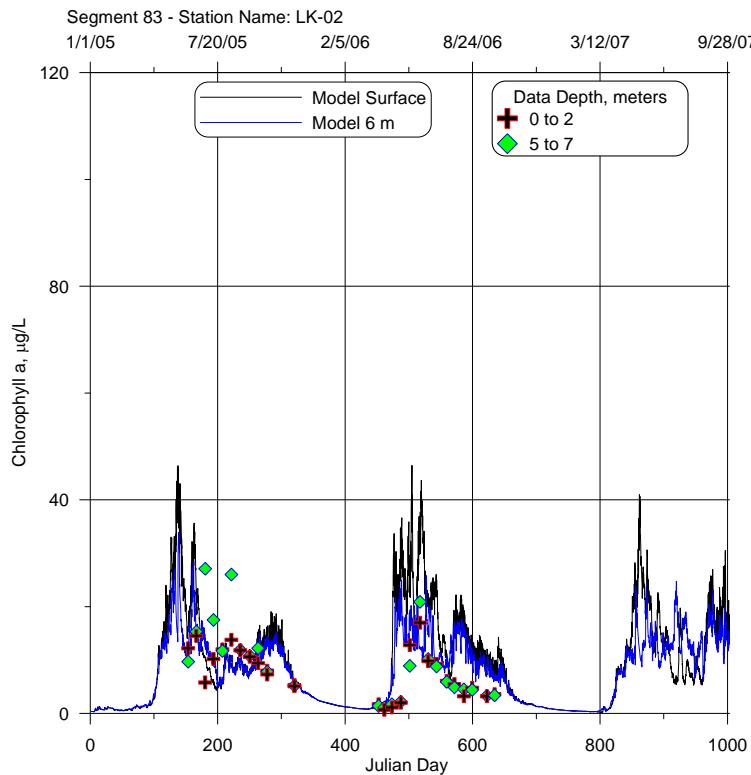


Figure 129. Chlorophyll a model vs. data comparison – segment 83 during calibration period.

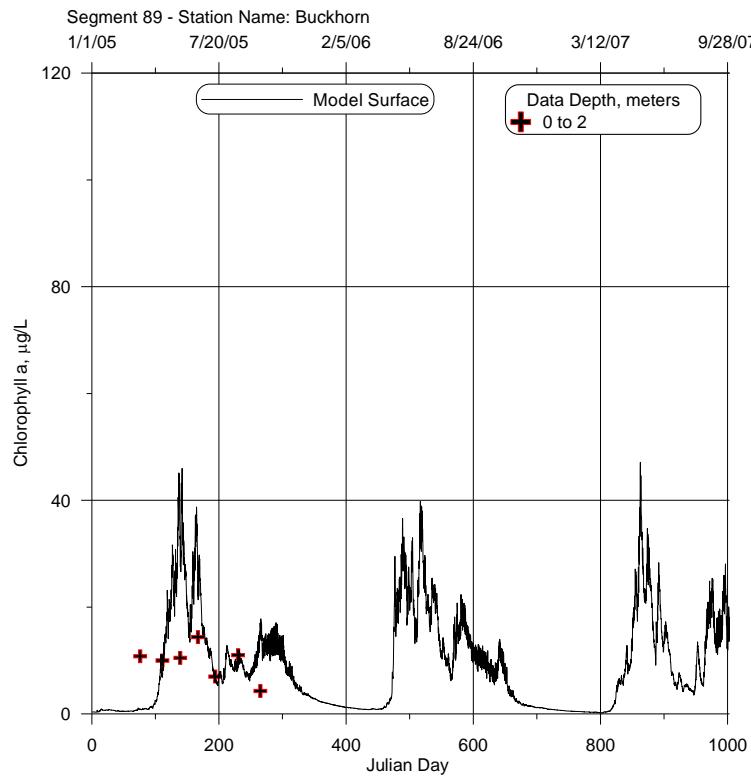


Figure 130. Chlorophyll a model vs. data comparison – segment 89 during calibration period.

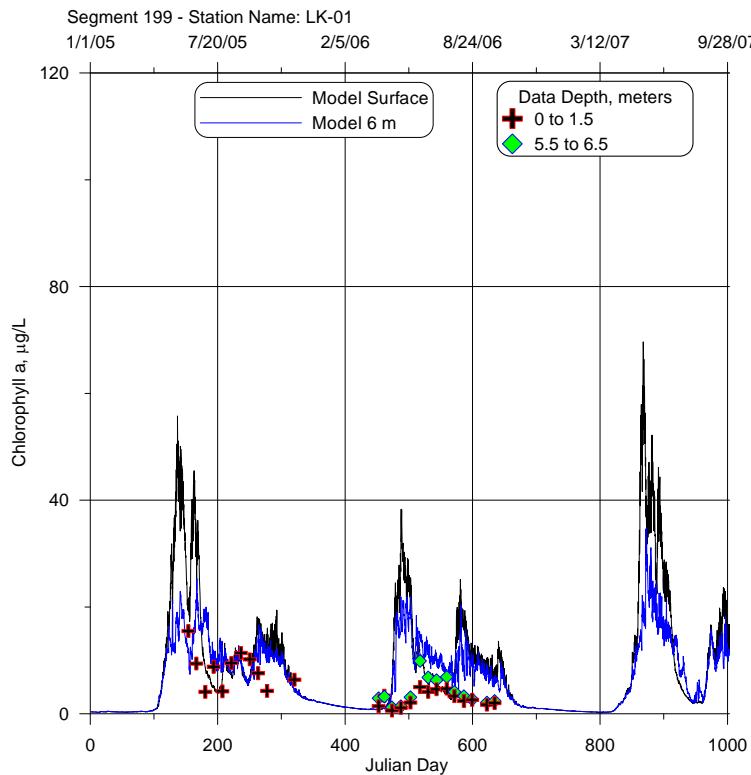


Figure 131. Chlorophyll a model vs. data comparison – segment 199 during calibration period.

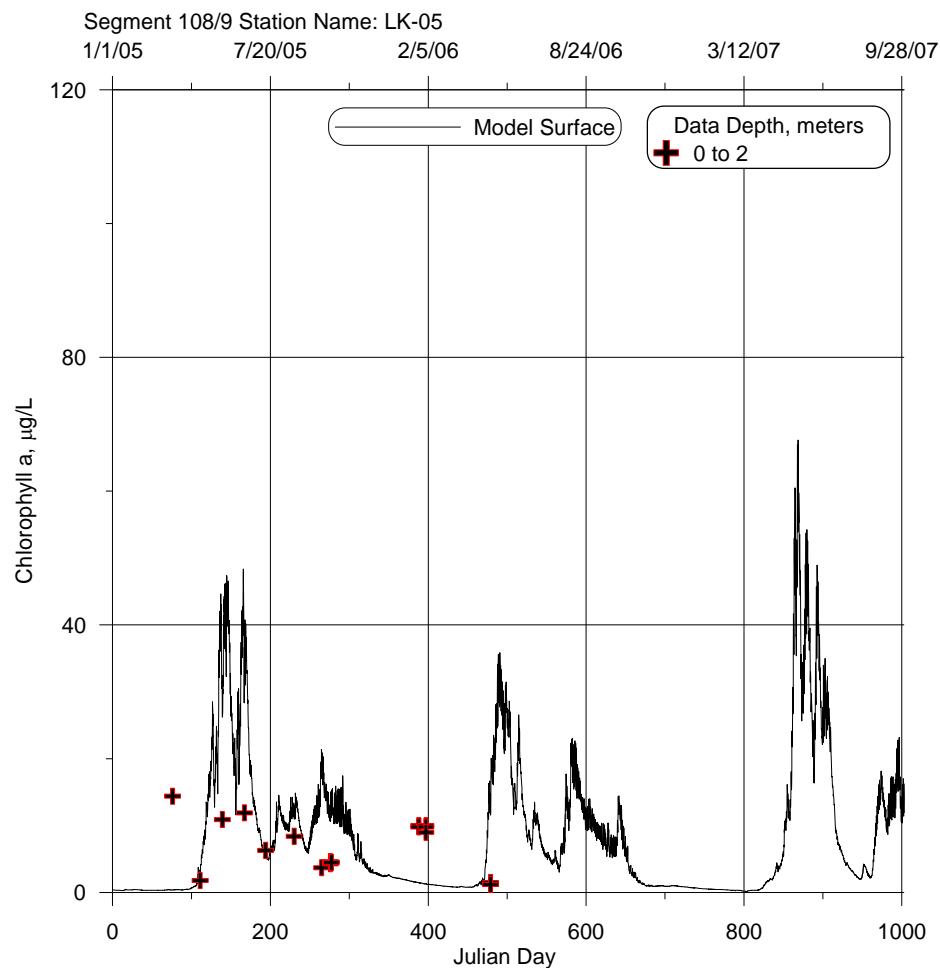


Figure 132. Chlorophyll a model vs. data comparison – segment 108/9 during calibration period.

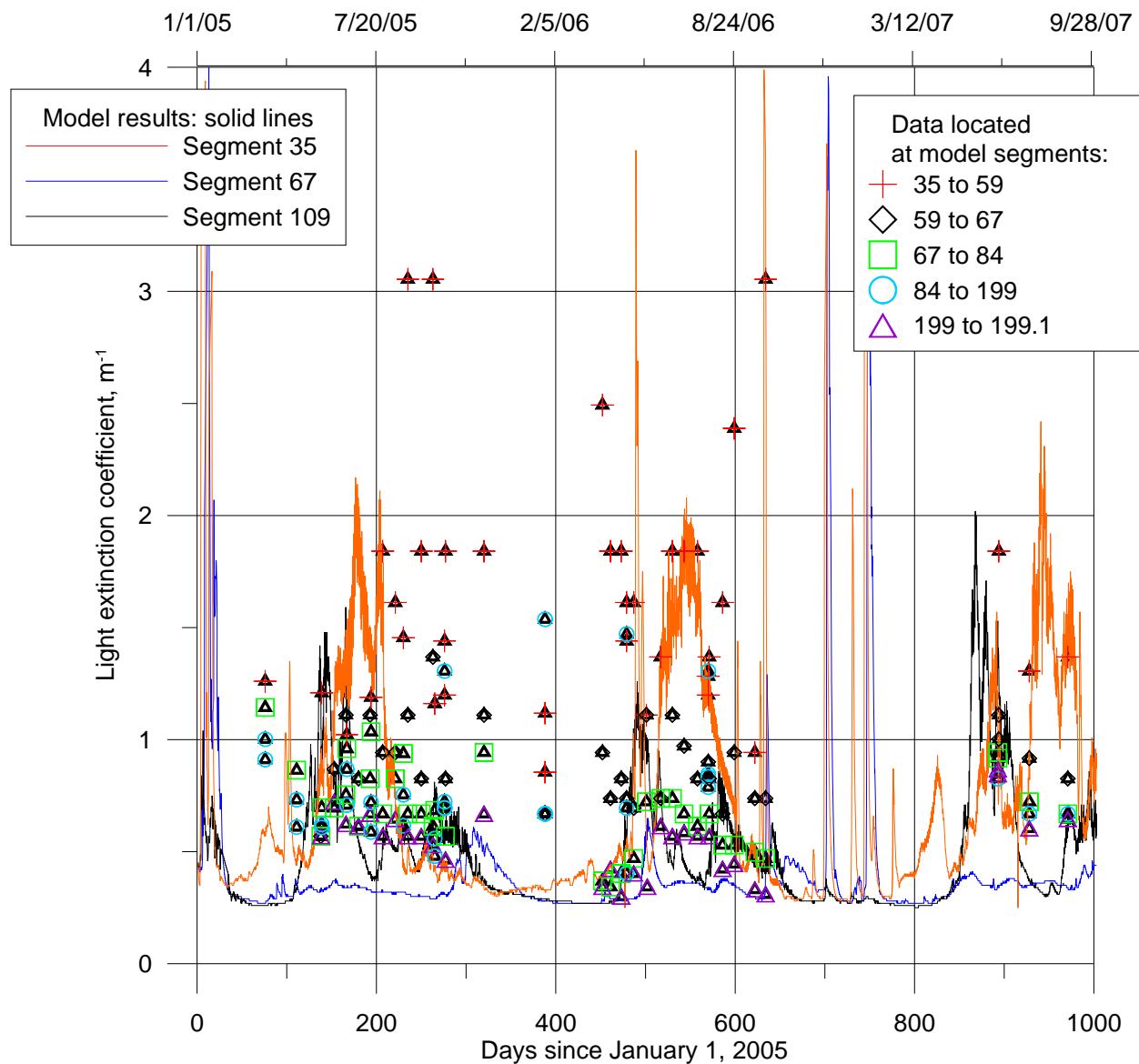


Figure 134. Model predictions of light extinction at the near surface compared to light extinction coefficients computed from Secchi disk depths.

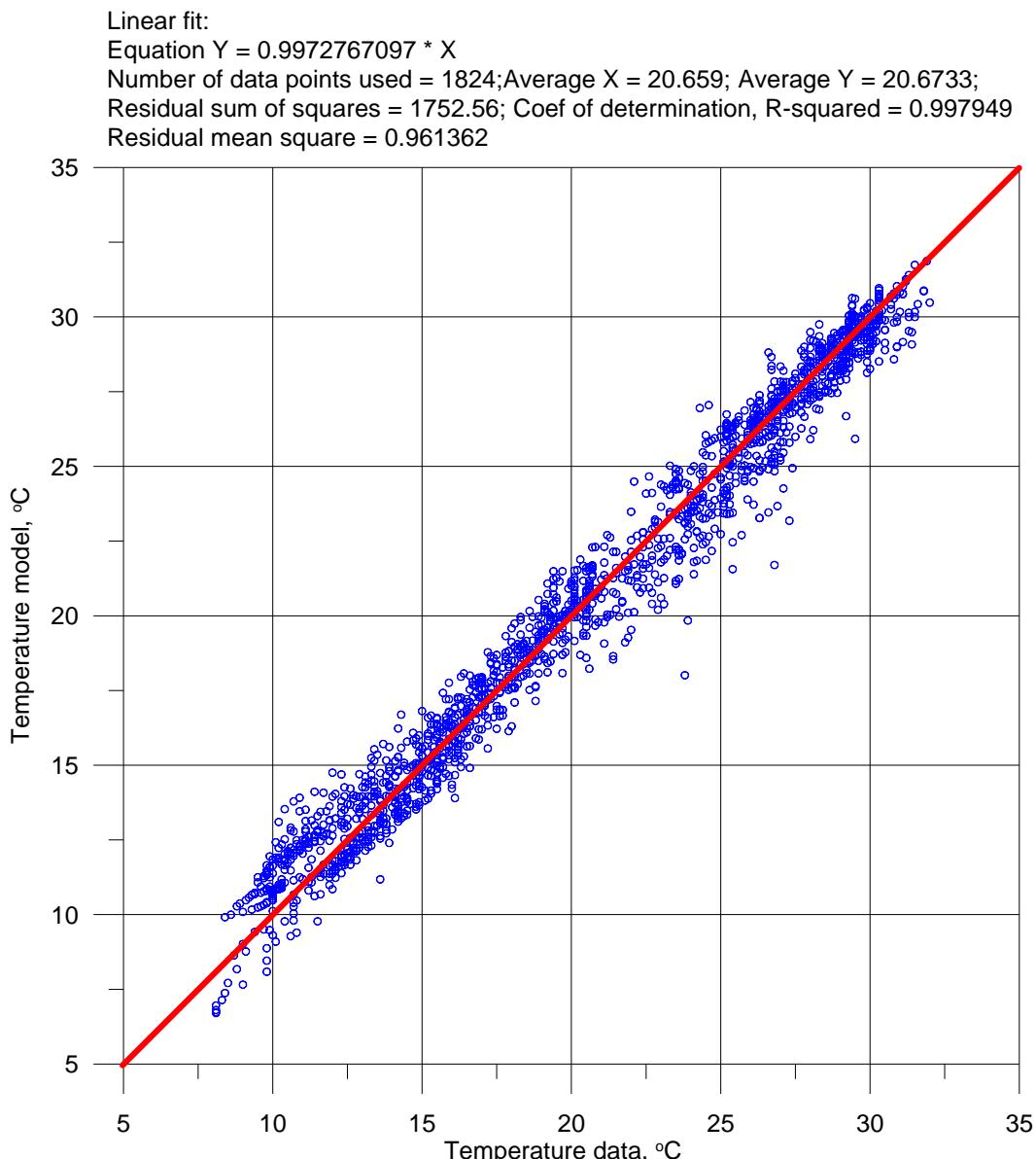


Figure 135.. Temperature field data compared to model predictions at all locations and times.

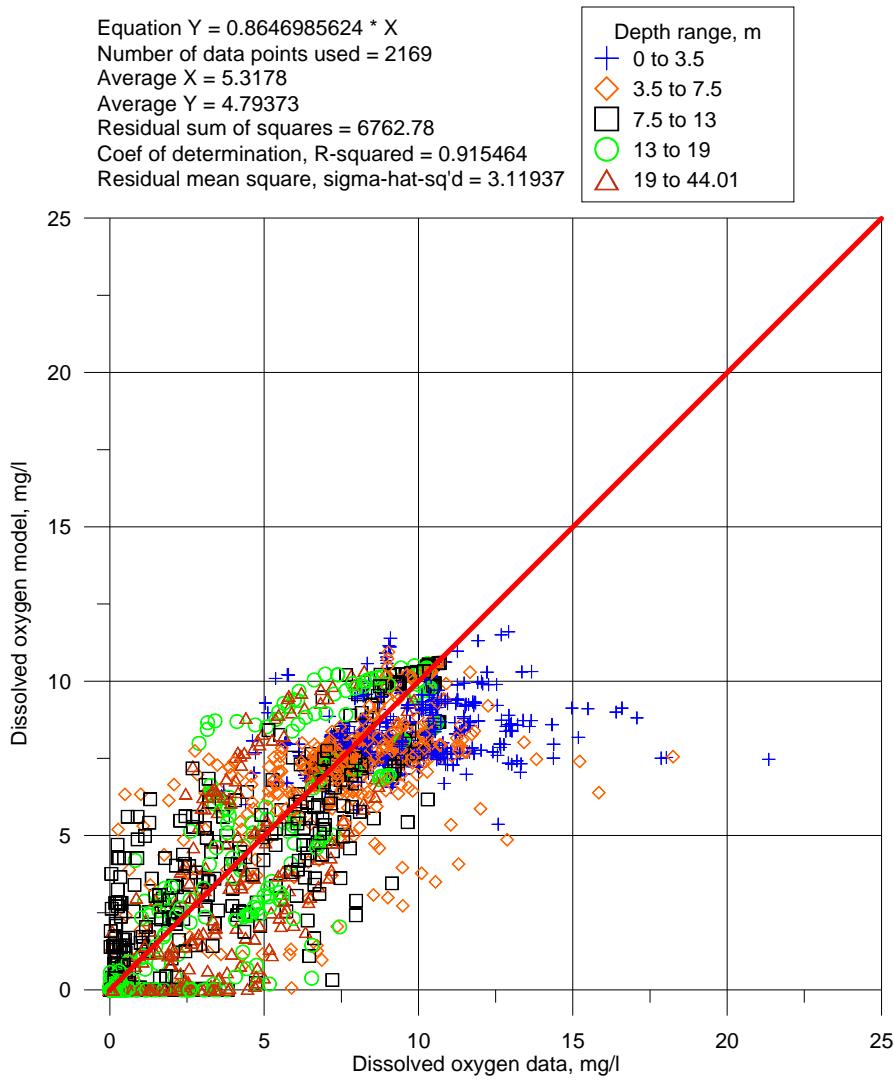


Figure 136. Dissolved oxygen field data compared to model predictions at all stations and times at different depths.

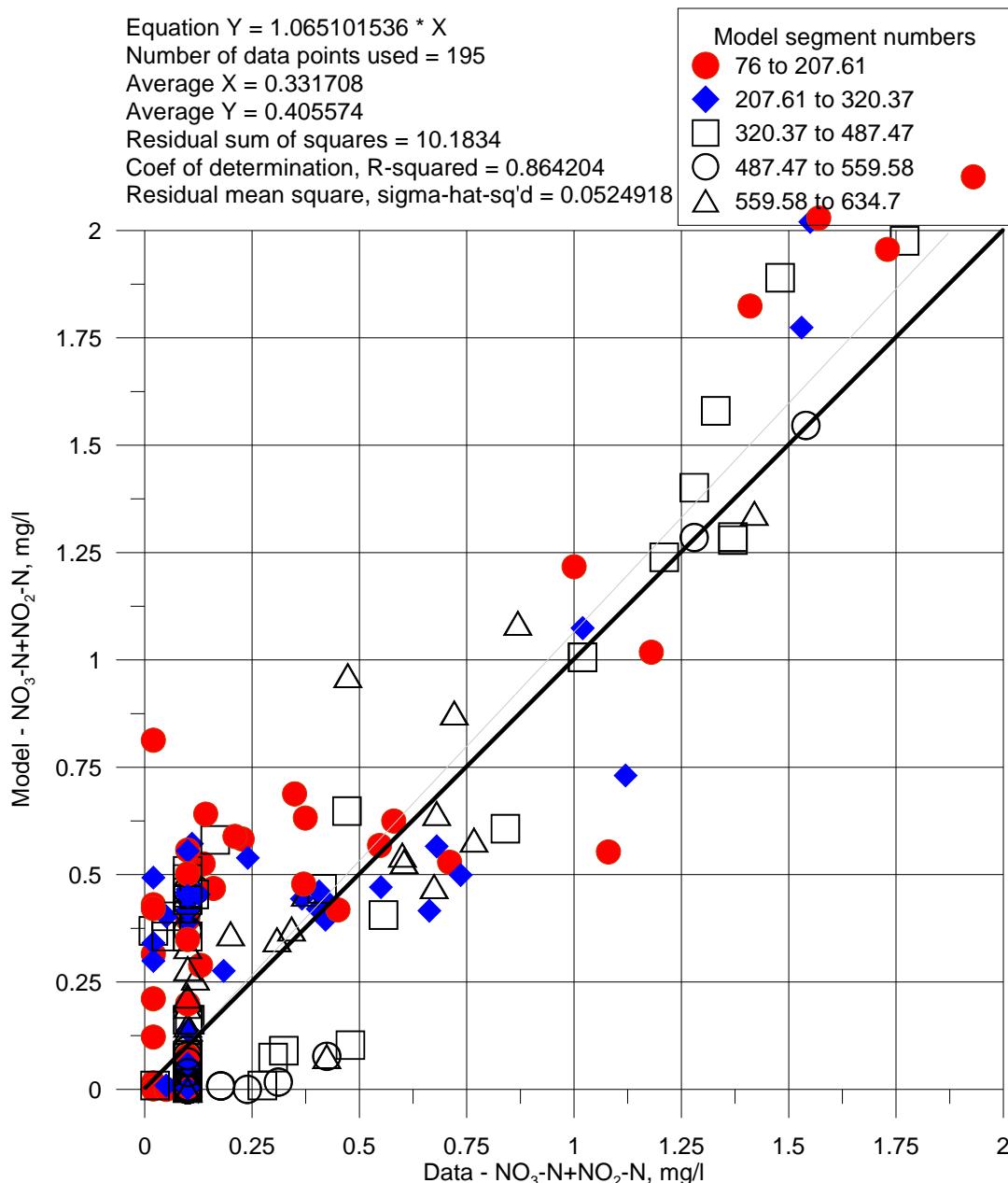


Figure 137. $\text{NO}_3\text{-N}$ field data compared to model predictions at all stations and times at different depths.

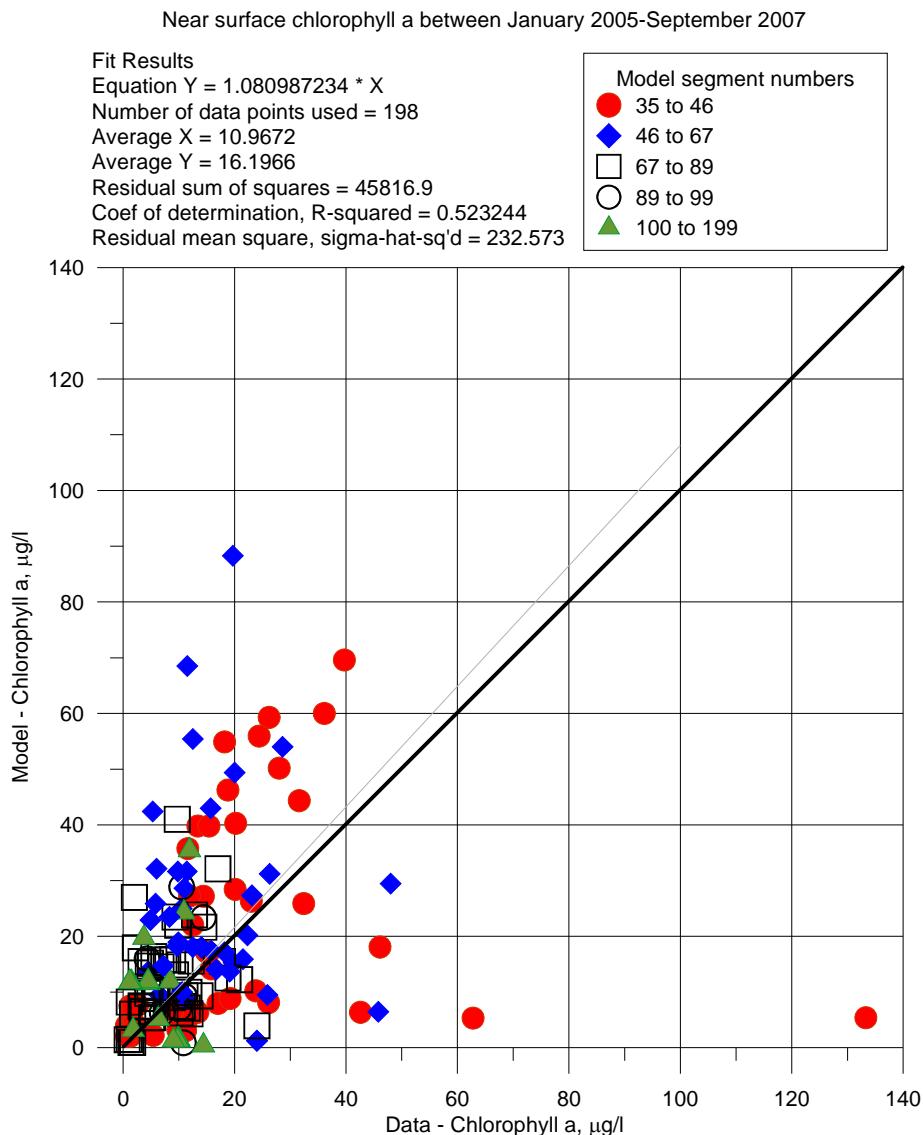


Figure 138. Model predictions of chlorophyll a compared to all field data during calibration period for all stations.

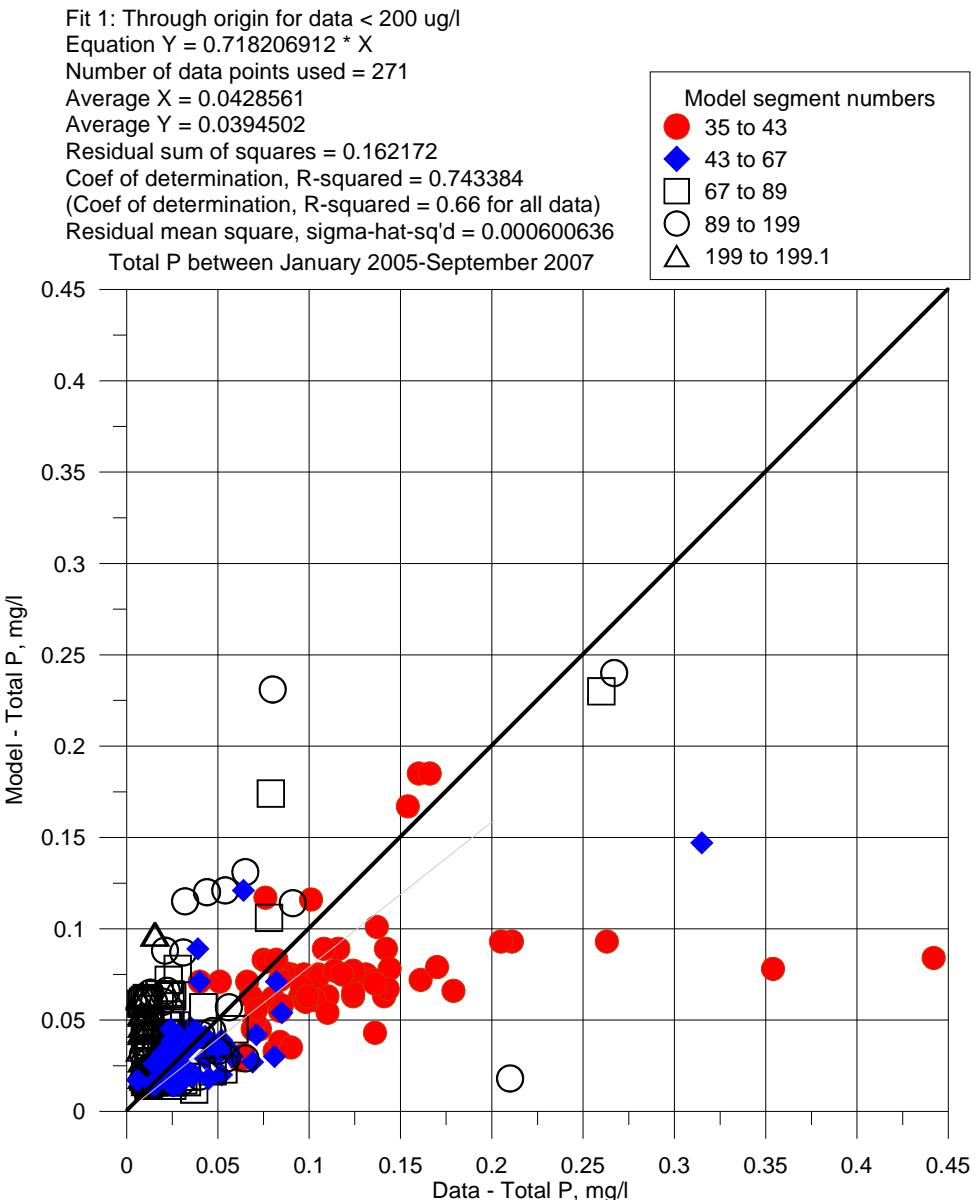


Figure 139. Model predicted Total P compared to field data for all stations during calibration period.

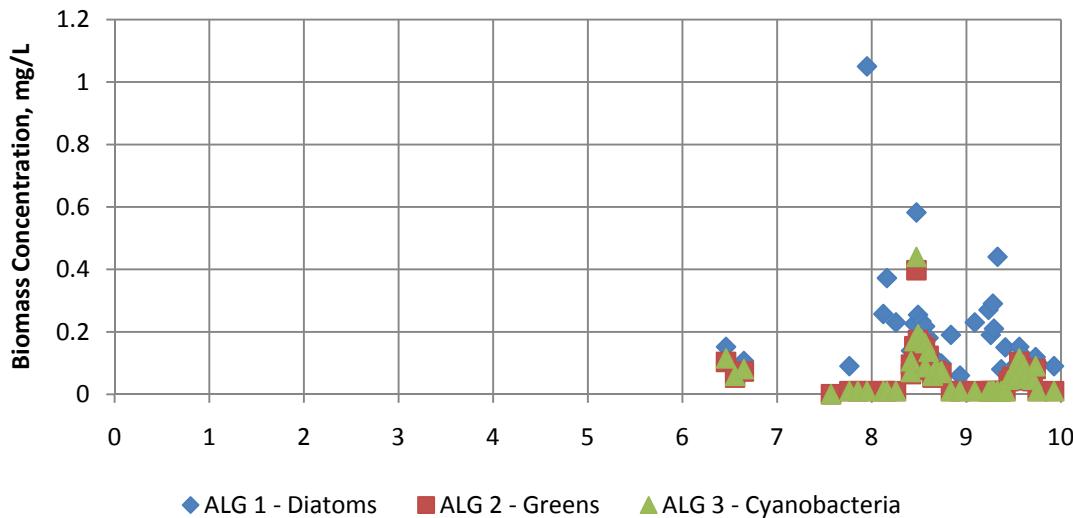


Figure 143. Illinois River algae group biomass concentrations for the base 10-year period of the 50-year model scenario.

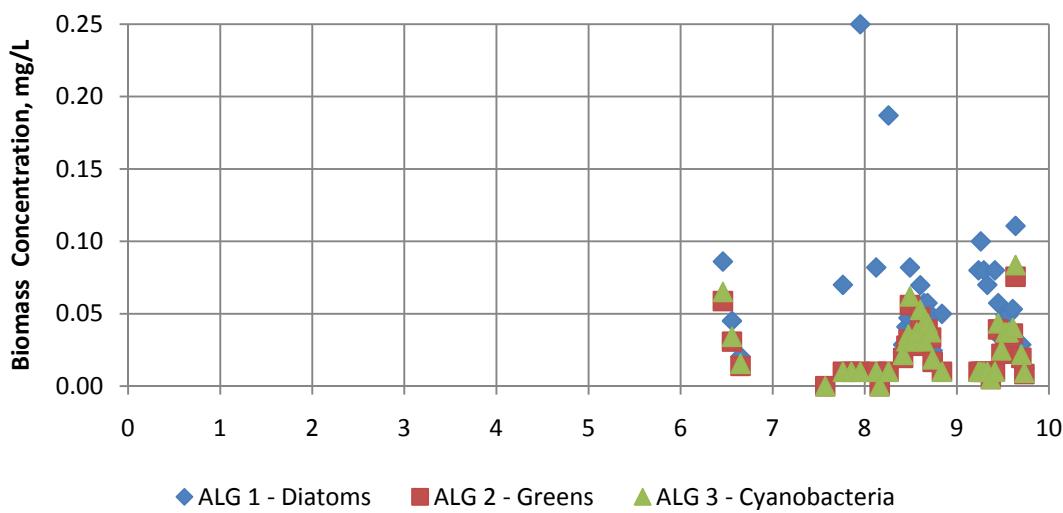


Figure 148. Baron Fork Creek algae group biomass concentrations for the base 10-year period of the 50-year model scenario.

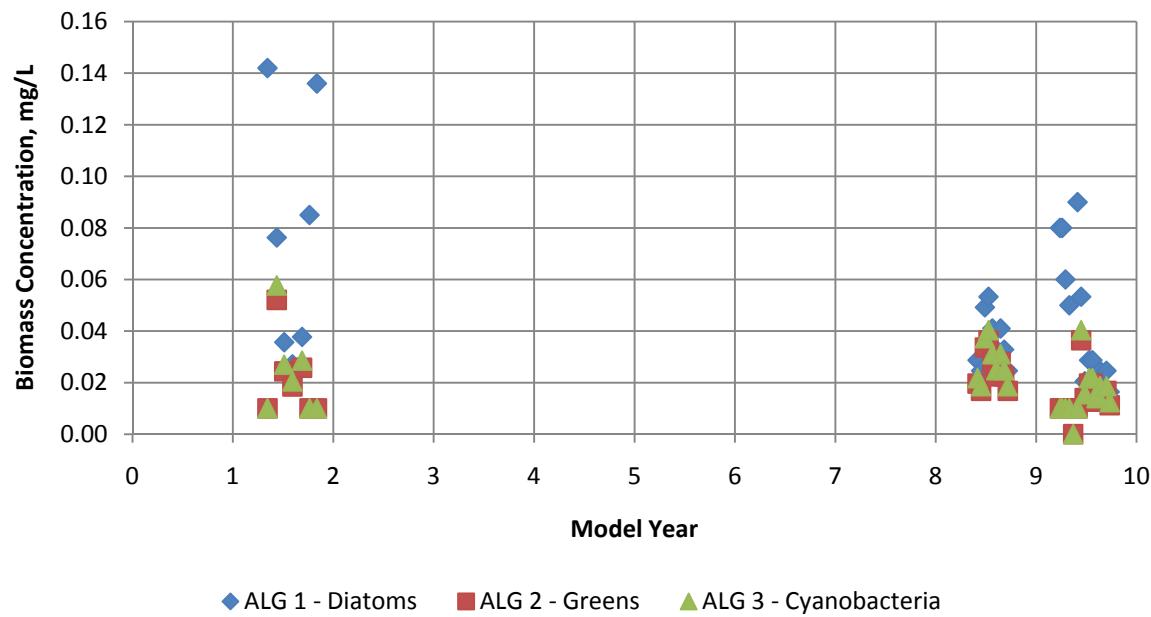


Figure 151. Caney Creek algae group biomass concentrations for the base 10-year period of the 50-year

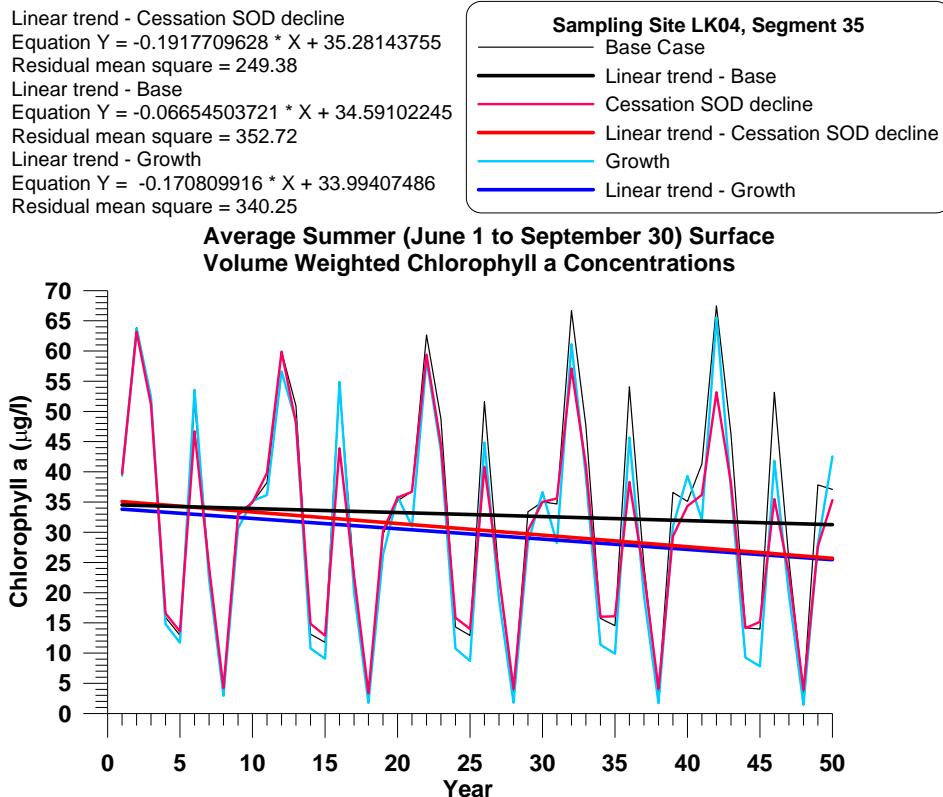


Figure 165. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK04, model segment 35 comparing cessation, growth and base case trends.

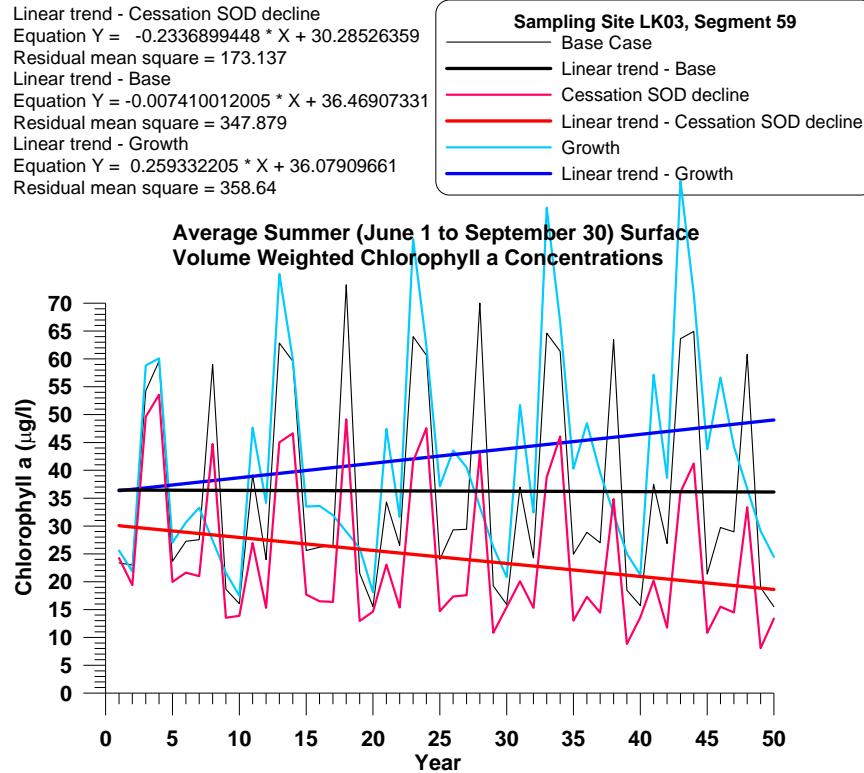


Figure 166. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK03, model segment 59 comparing cessation, growth and base case trends.

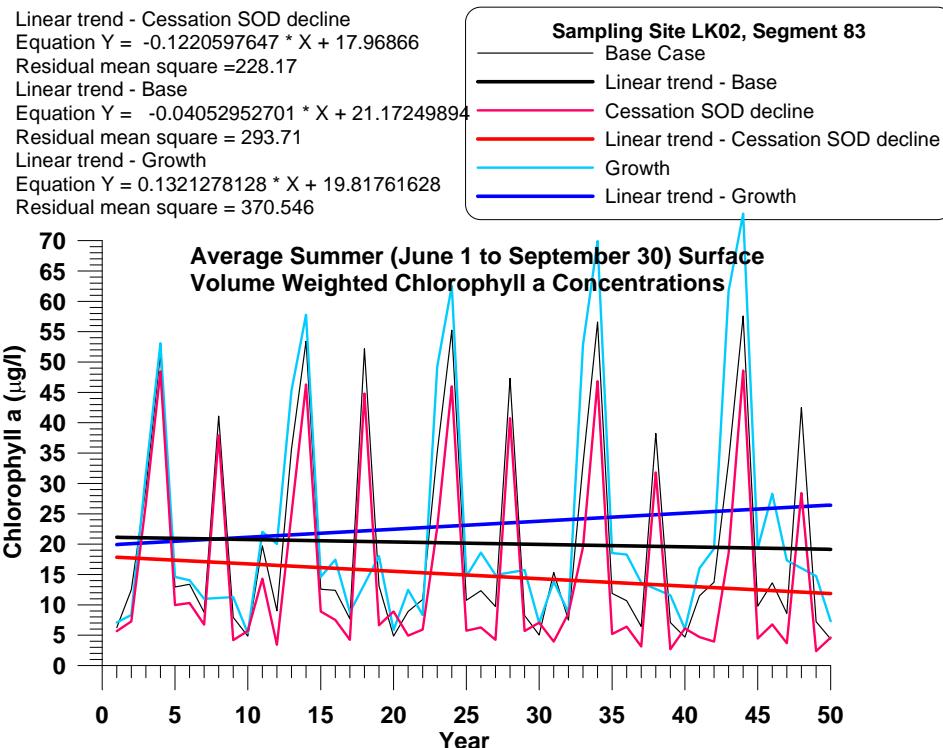


Figure 167. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK02, model segment 83 comparing cessation, growth and base case trends.

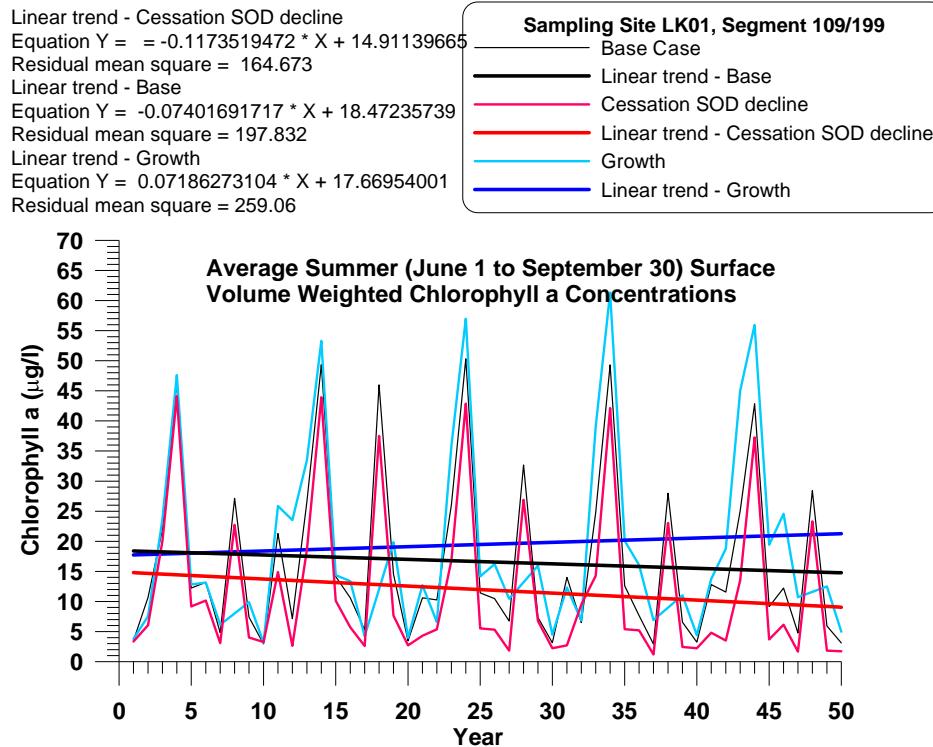


Figure 168. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK01, model segment 199 comparing cessation, growth and base case trends.

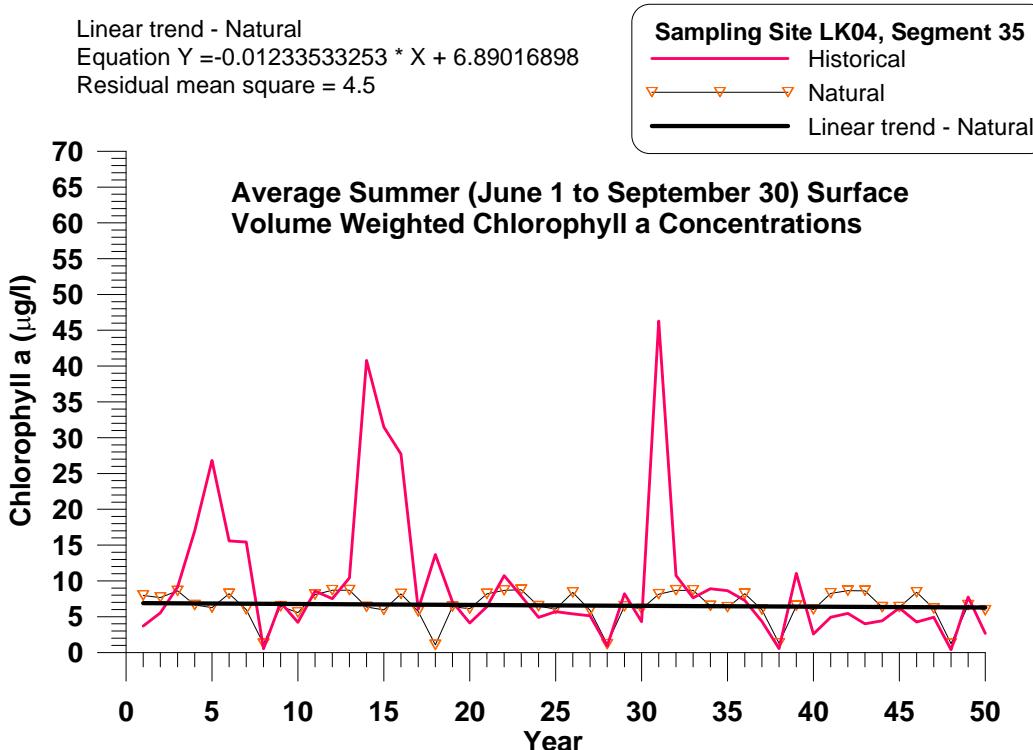


Figure 169. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK04, model segment 35 for historical and natural cases.

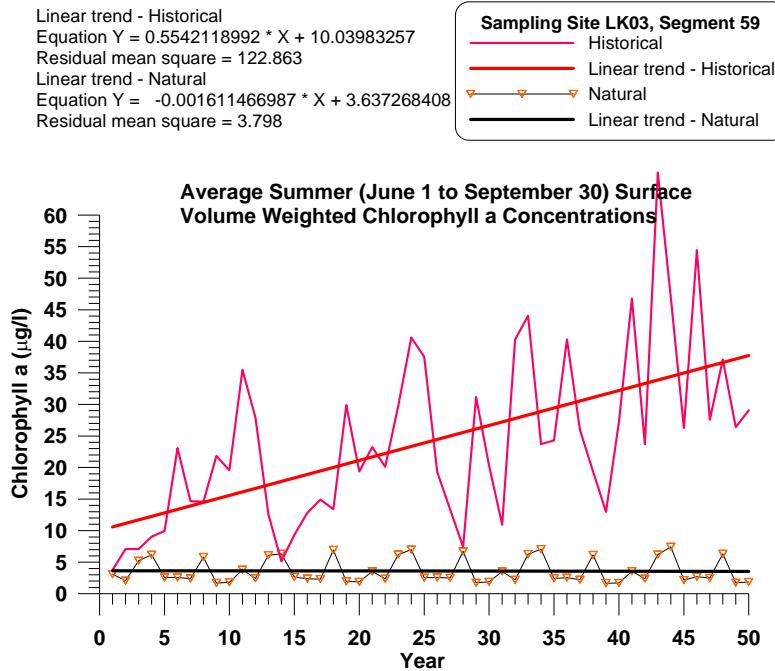


Figure 170. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK03, model segment 59 for historical and natural cases.

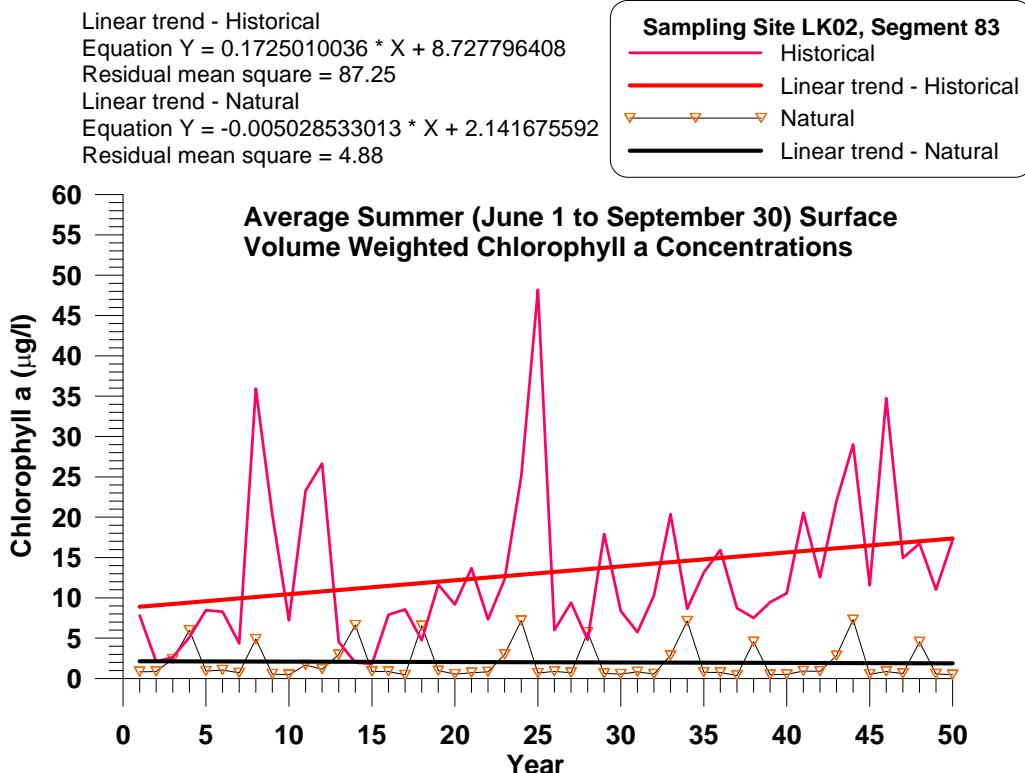


Figure 171. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK02, model segment 83 for historical and natural cases.

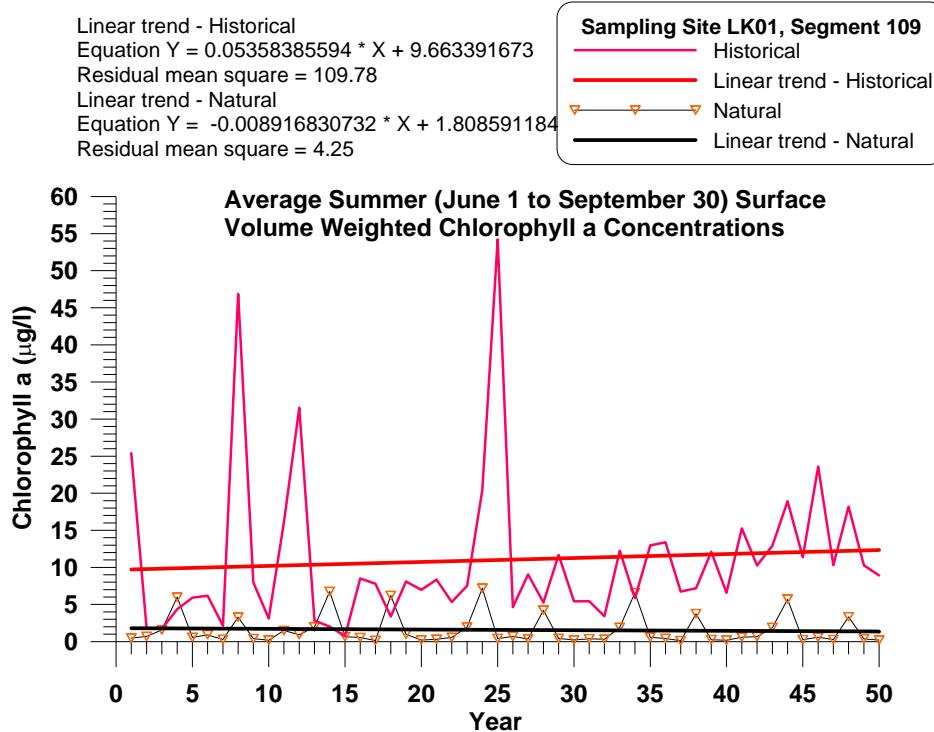


Figure 172. Volume weighted surface (5-6 m depth) average chlorophyll a at sampling site LK01, model segment 109 for historical and natural cases.

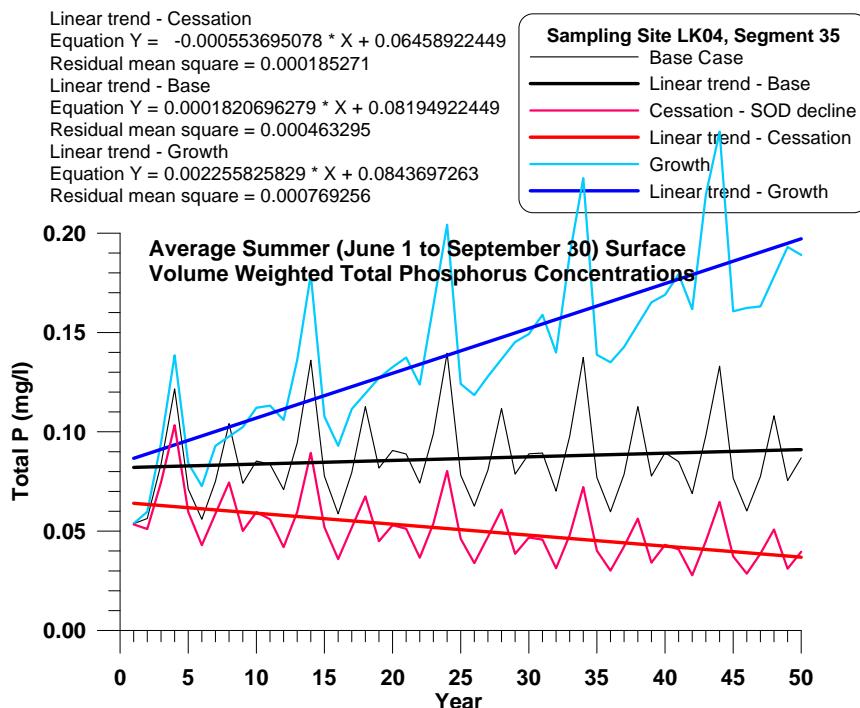


Figure 173. Volume weighted surface (5-6 m depth) average Total P at sampling site LK04, model segment 35 comparing cessation and base case trends.

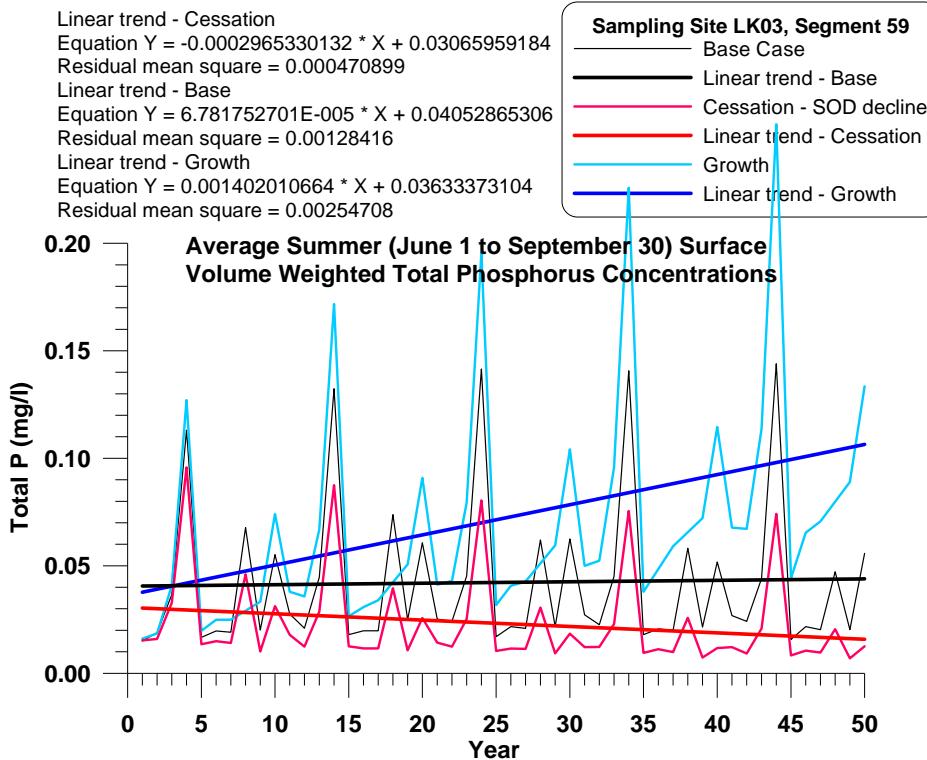


Figure 174. Volume weighted surface (5-6 m depth) average Total P at sampling site LK03, model segment 59 comparing cessation and base case trends.

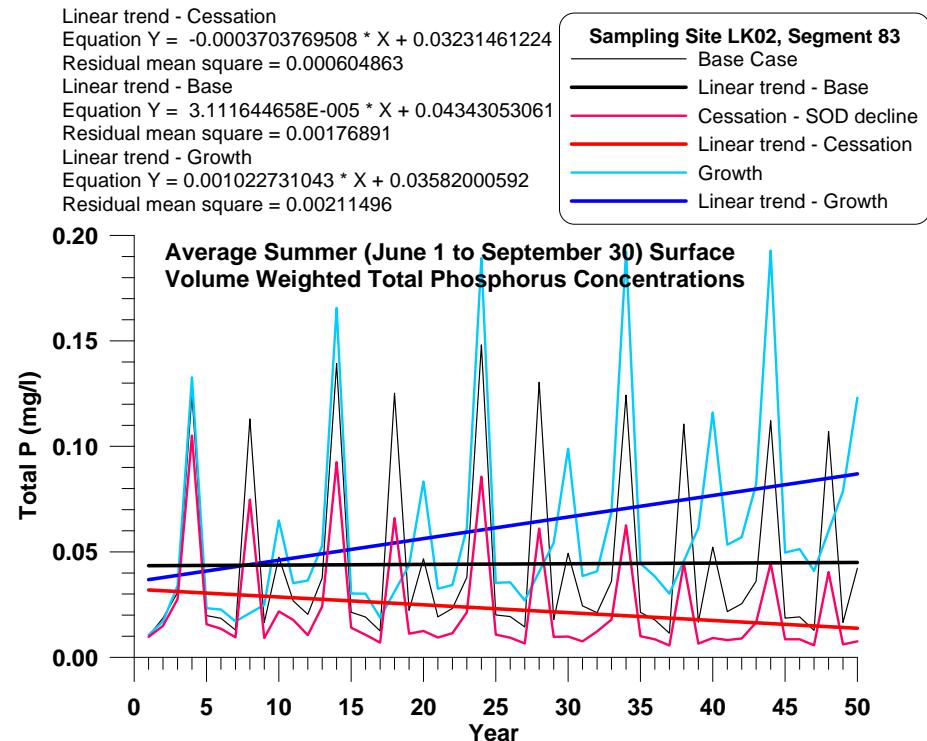


Figure 175. Volume weighted surface (5-6 m depth) average Total P at sampling site LK02, model segment 83 comparing cessation and base case trends.

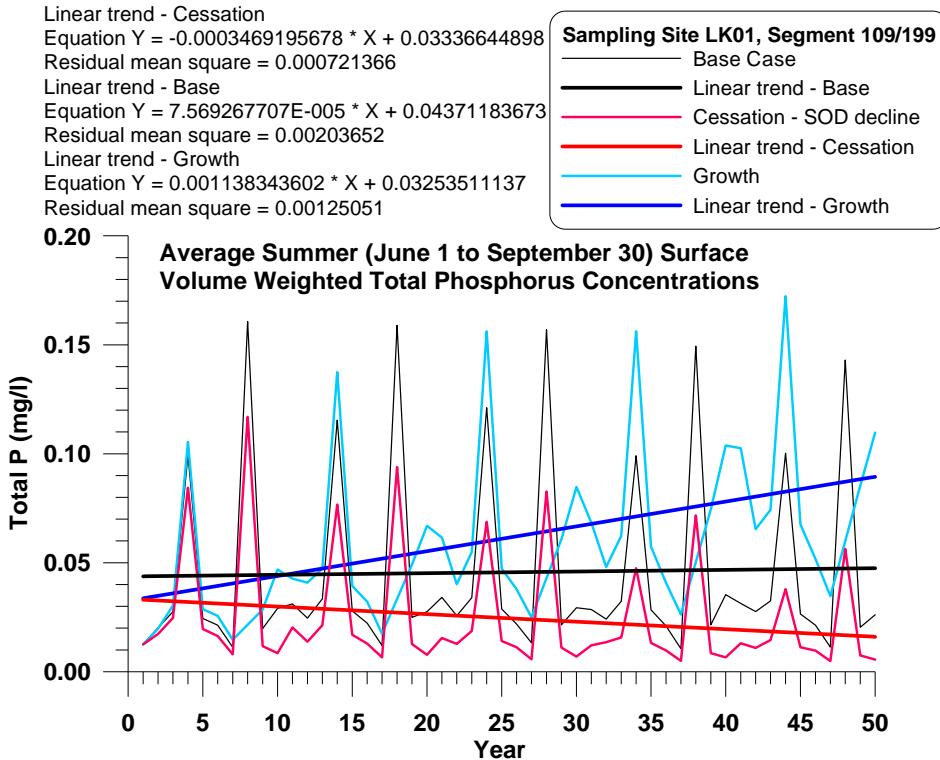


Figure 176. Volume weighted surface (5-6 m depth) average Total P at sampling site LK01, model segment 199 comparing cessation, growth and base case trends.

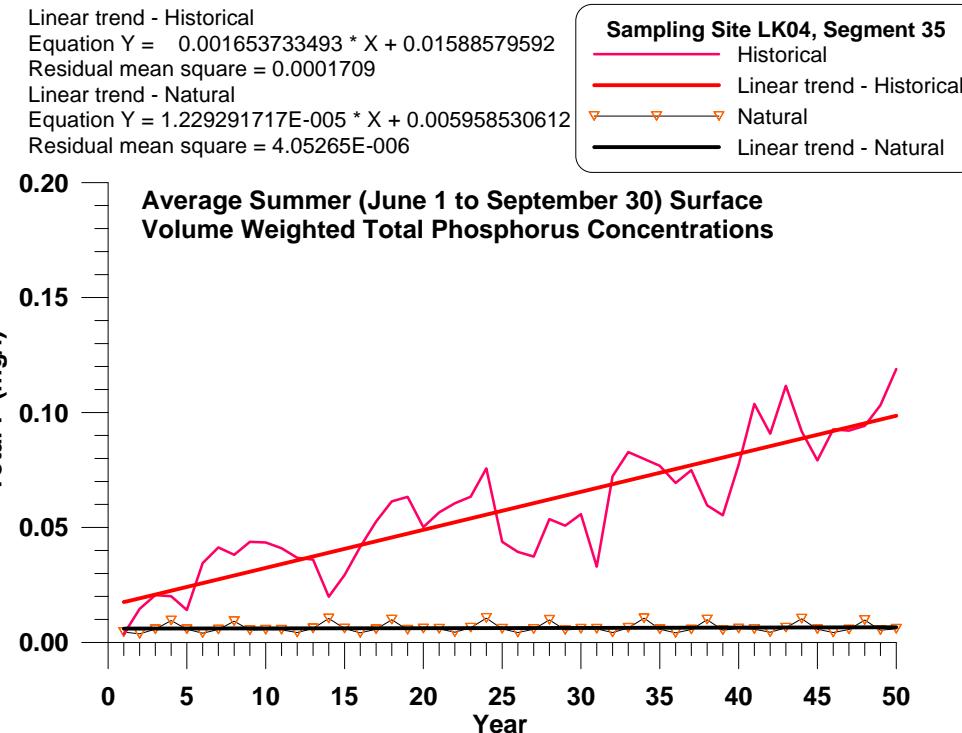


Figure 177. Volume weighted surface (5-6 m depth) average Total P at sampling site LK04, model segment 35 for historical and natural cases.

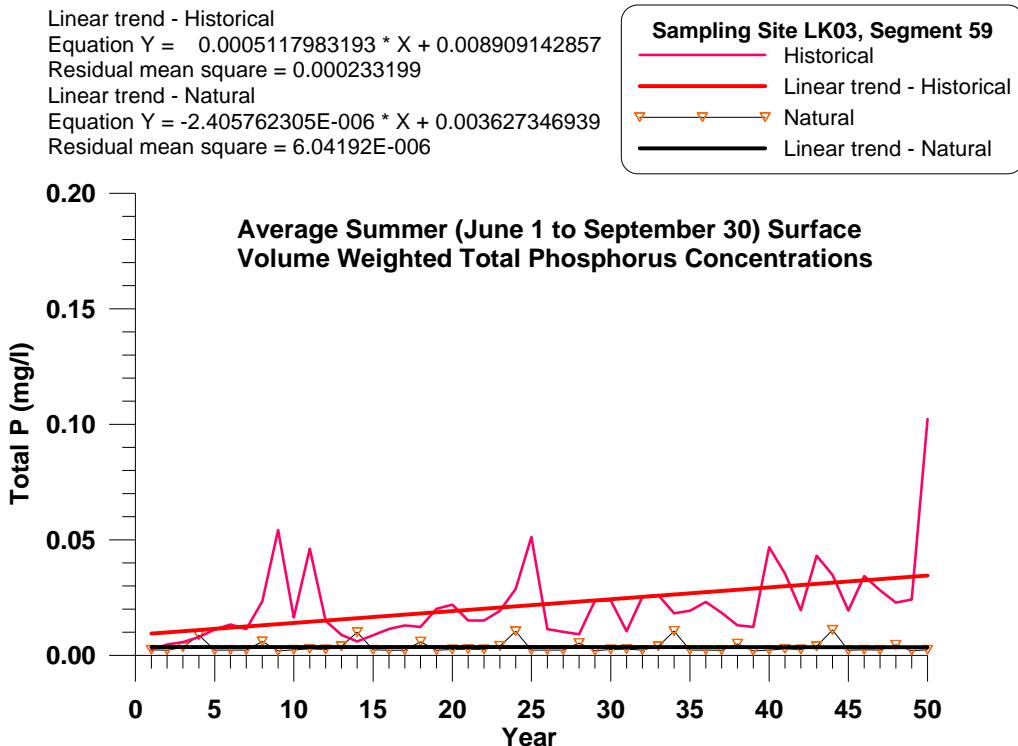


Figure 178. Volume weighted surface (5-6 m depth) average Total P at sampling site LK03, model segment 59 for historical and natural cases.

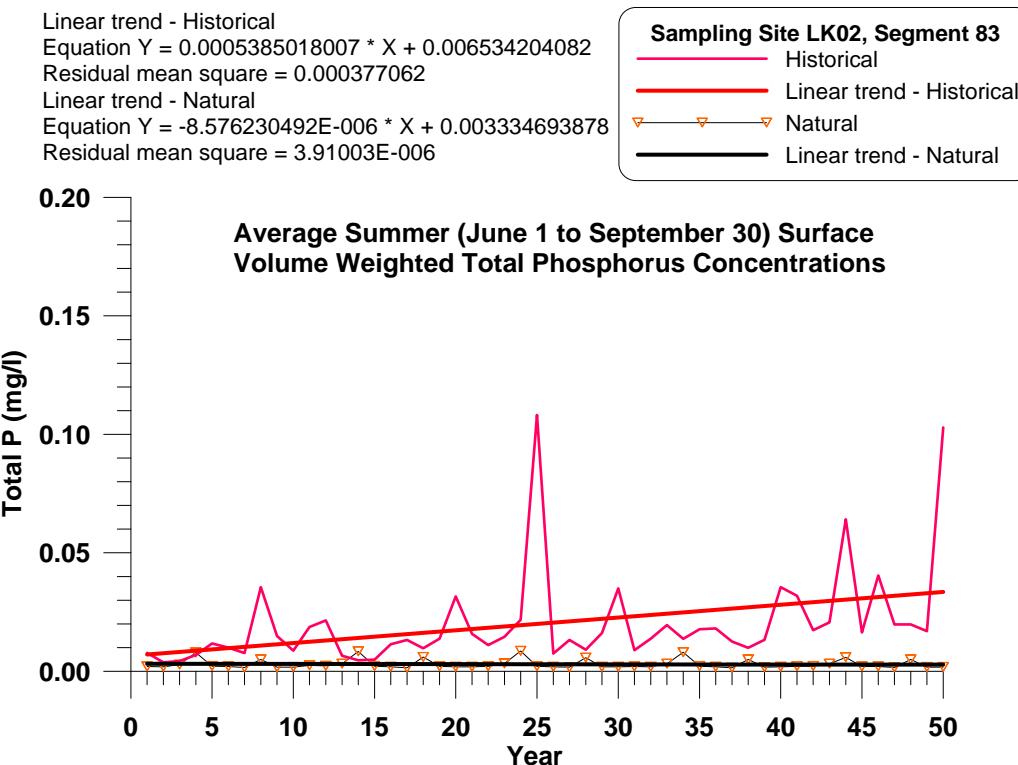


Figure 179. Volume weighted surface (5-6 m depth) average Total P at sampling site LK02, model segment 83 for historical and natural cases.

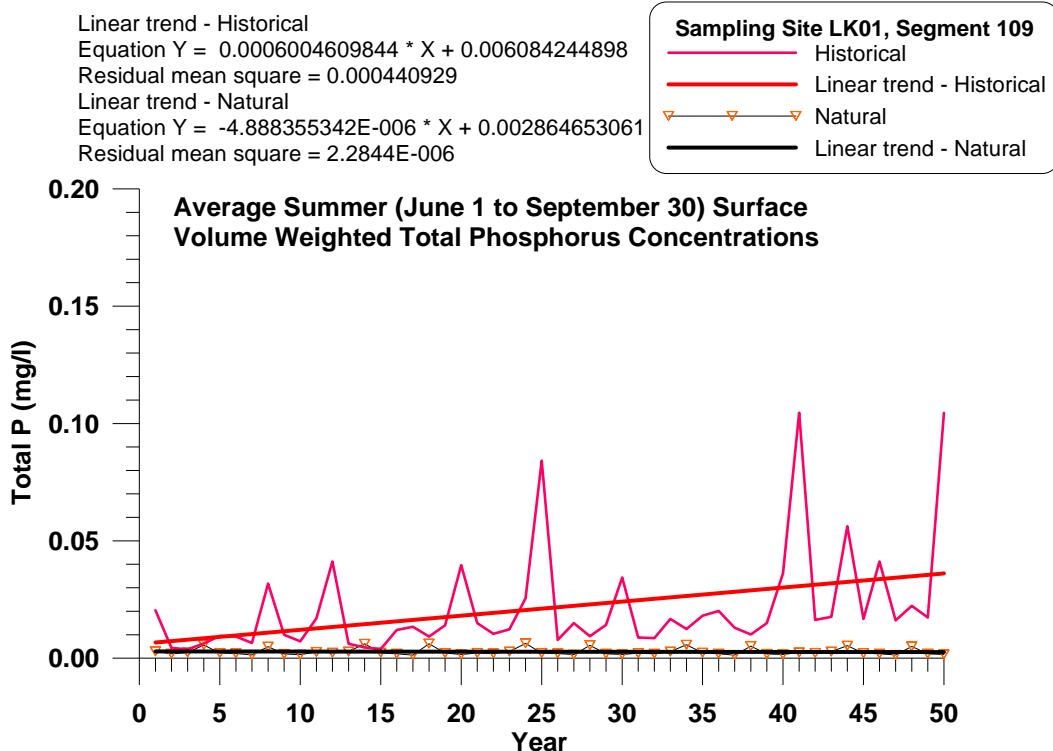


Figure 180. Volume weighted surface (5-6 m depth) average Total P at sampling site LK01, model segment 109(199) for growth, historical, and natural cases compared to base case.

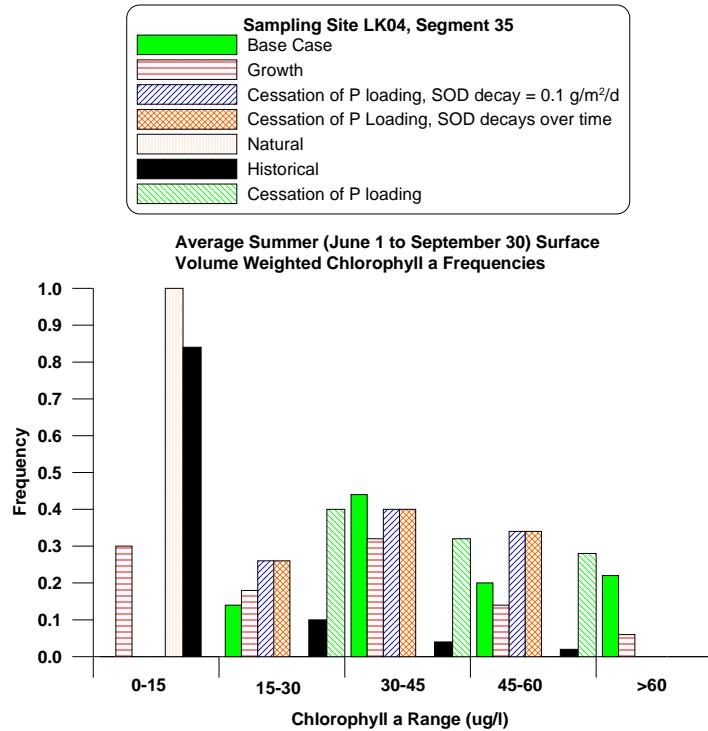


Figure 181. Frequency distribution for LK04 (segment 35) for chlorophyll a for summer surface layer over 50-year period.

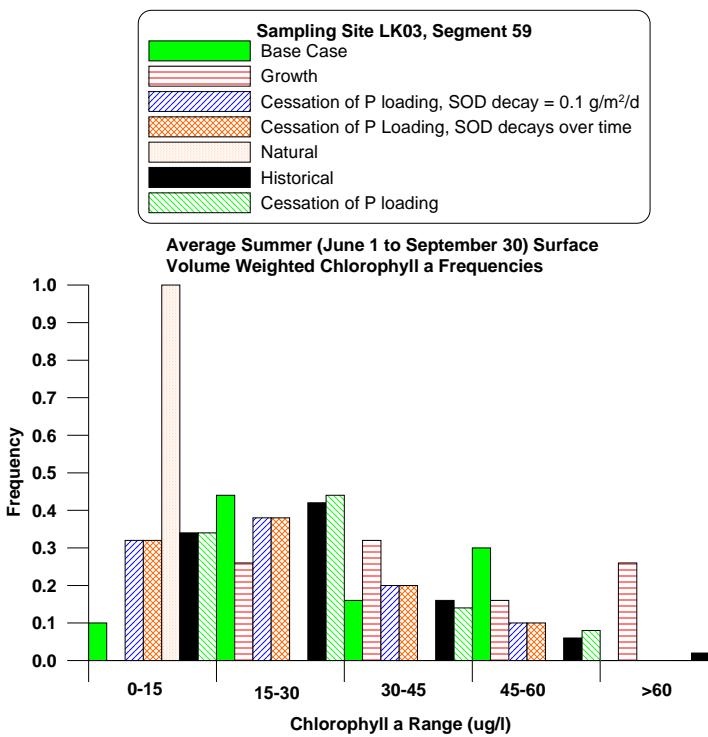


Figure 182. Frequency distribution for LK03 (segment 59) for chlorophyll a for summer surface layer over 50-year period.

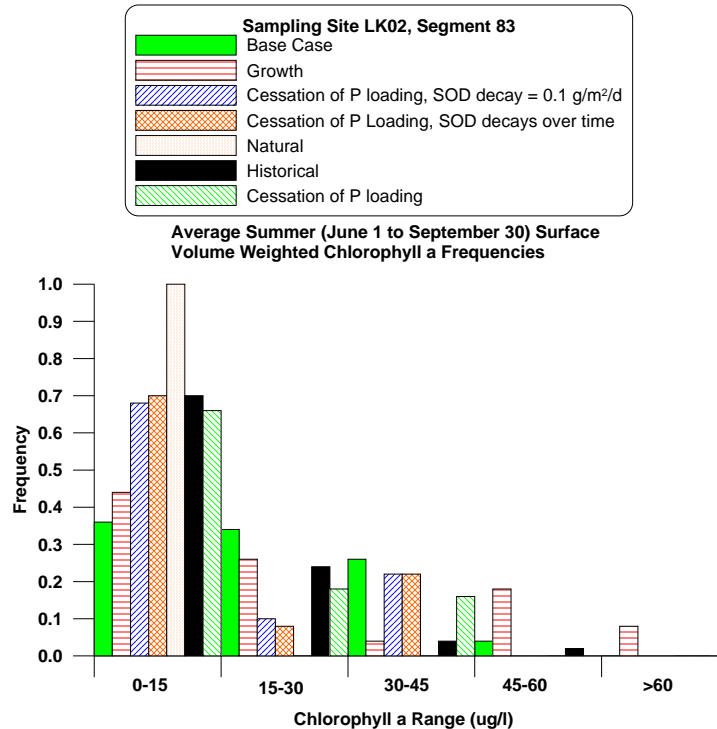


Figure 183. Frequency distribution for LK02 (segment 83) for chlorophyll a for summer surface layer over 50-year period.

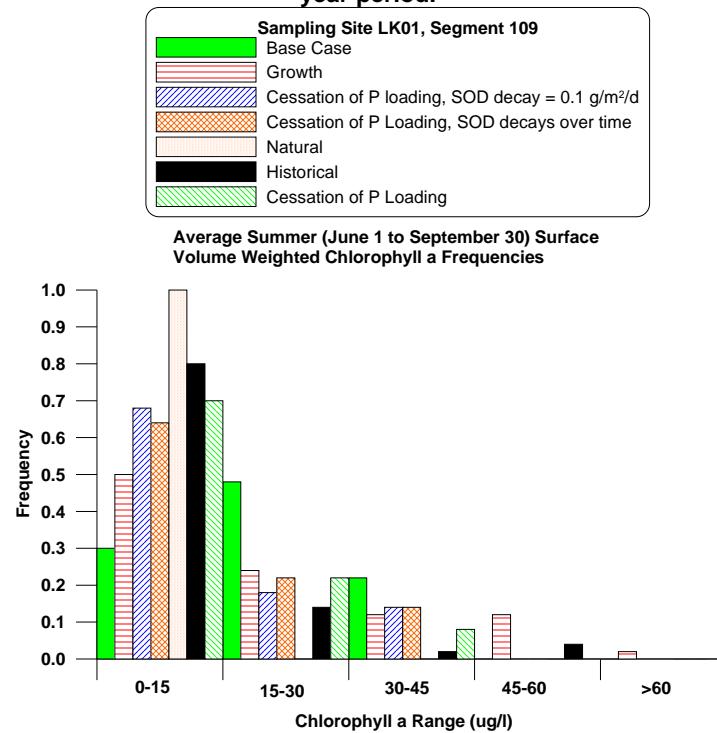


Figure 184. Frequency distribution for LK01 (segment 109) for chlorophyll a for summer surface layer over 50-year period.

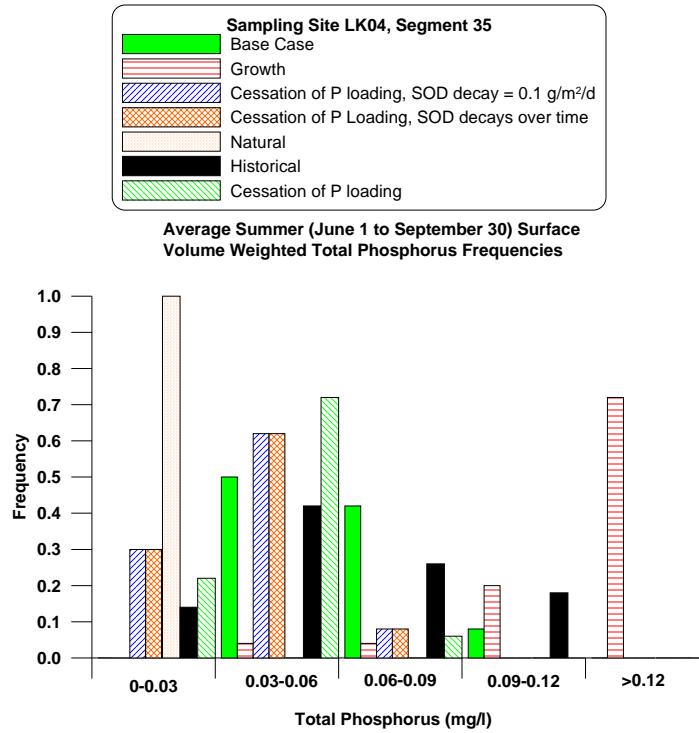


Figure 185. Frequency distribution for LK04 (segment 35) for Total P for summer surface layer over 50-year period.

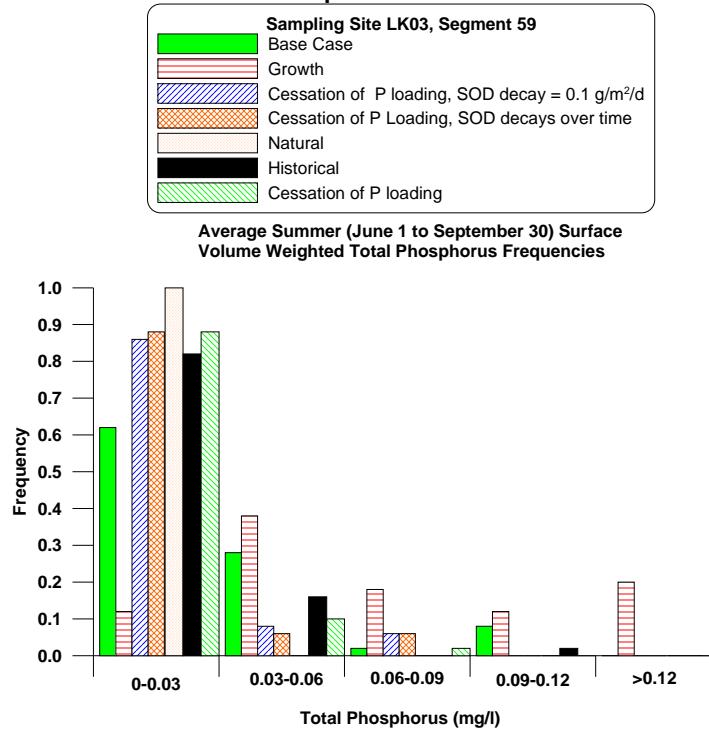


Figure 186. Frequency distribution for LK03 (segment 59) for Total P for summer surface layer over 50-year period.

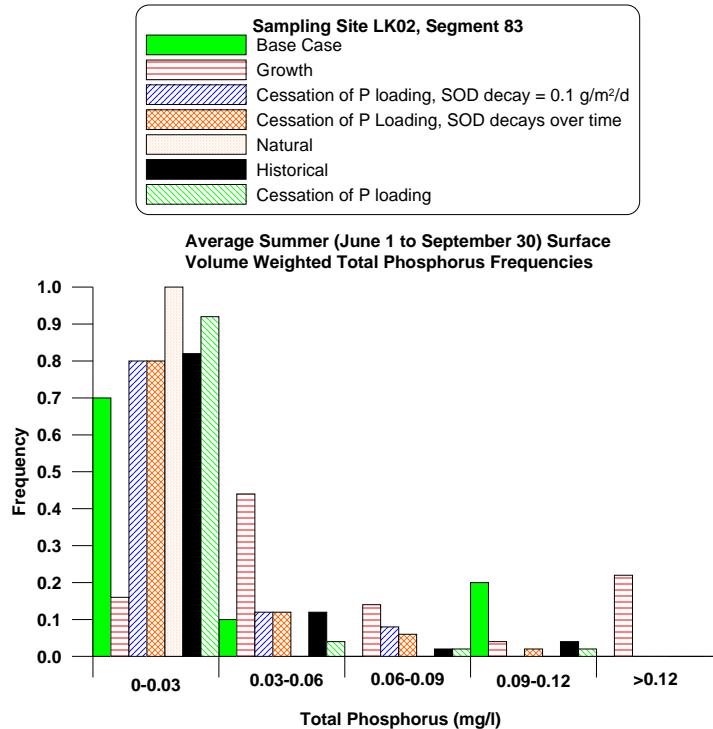


Figure 1 187. Frequency distribution for LK02 (segment 83) for Total P for summer surface layer over 50-year period.

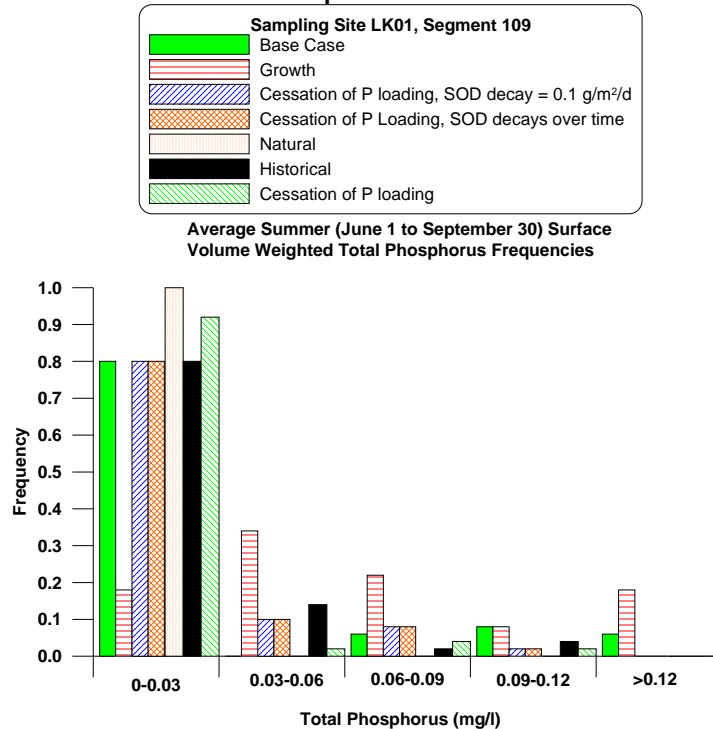


Figure 188. Frequency distribution for LK01 (segment 109) for Total P for summer surface layer over 50-year

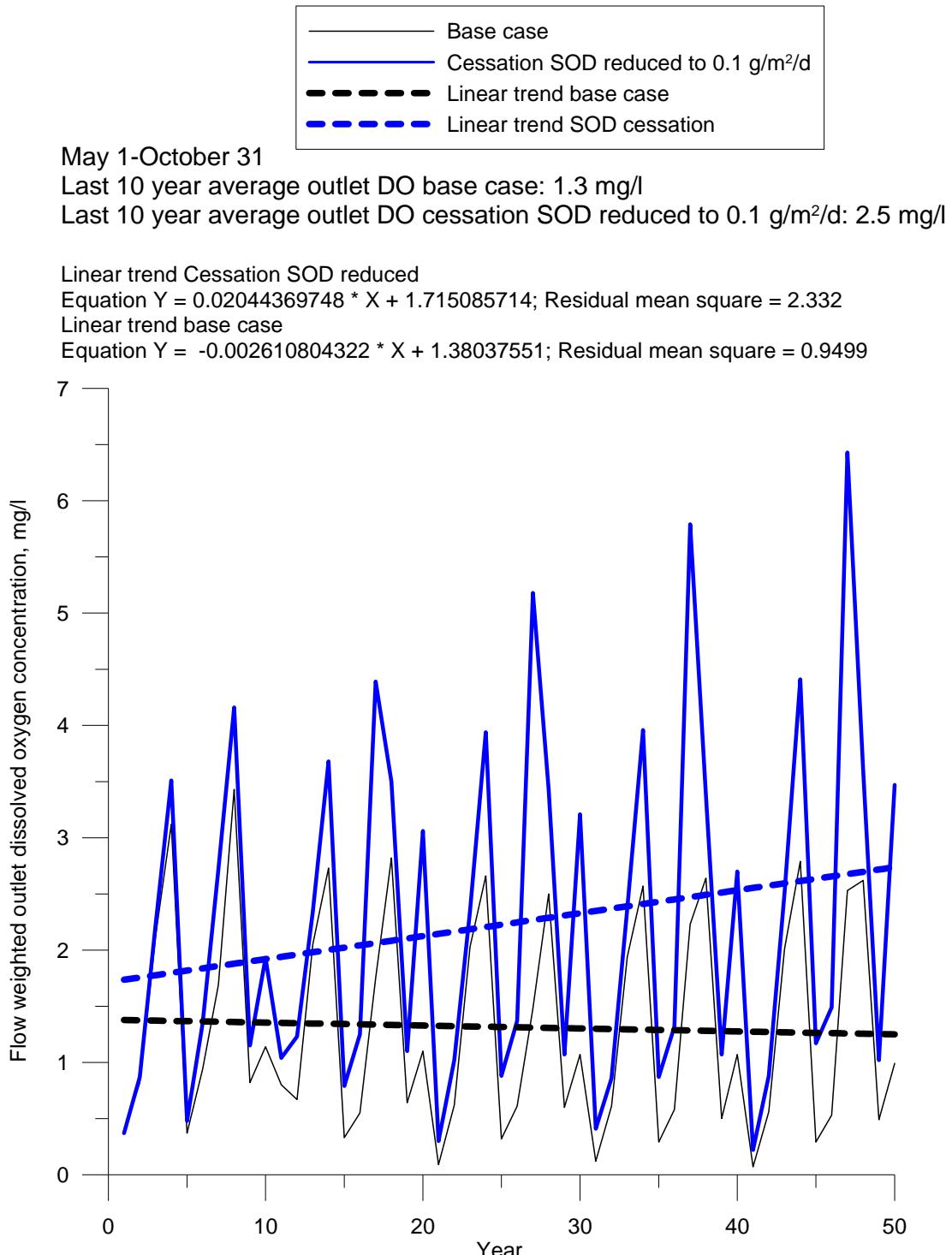


Figure 189. Average dissolved oxygen between May 1 and October 31 of each year for the base case and the cessation with SOD declining to 0.1 g/m²/d.

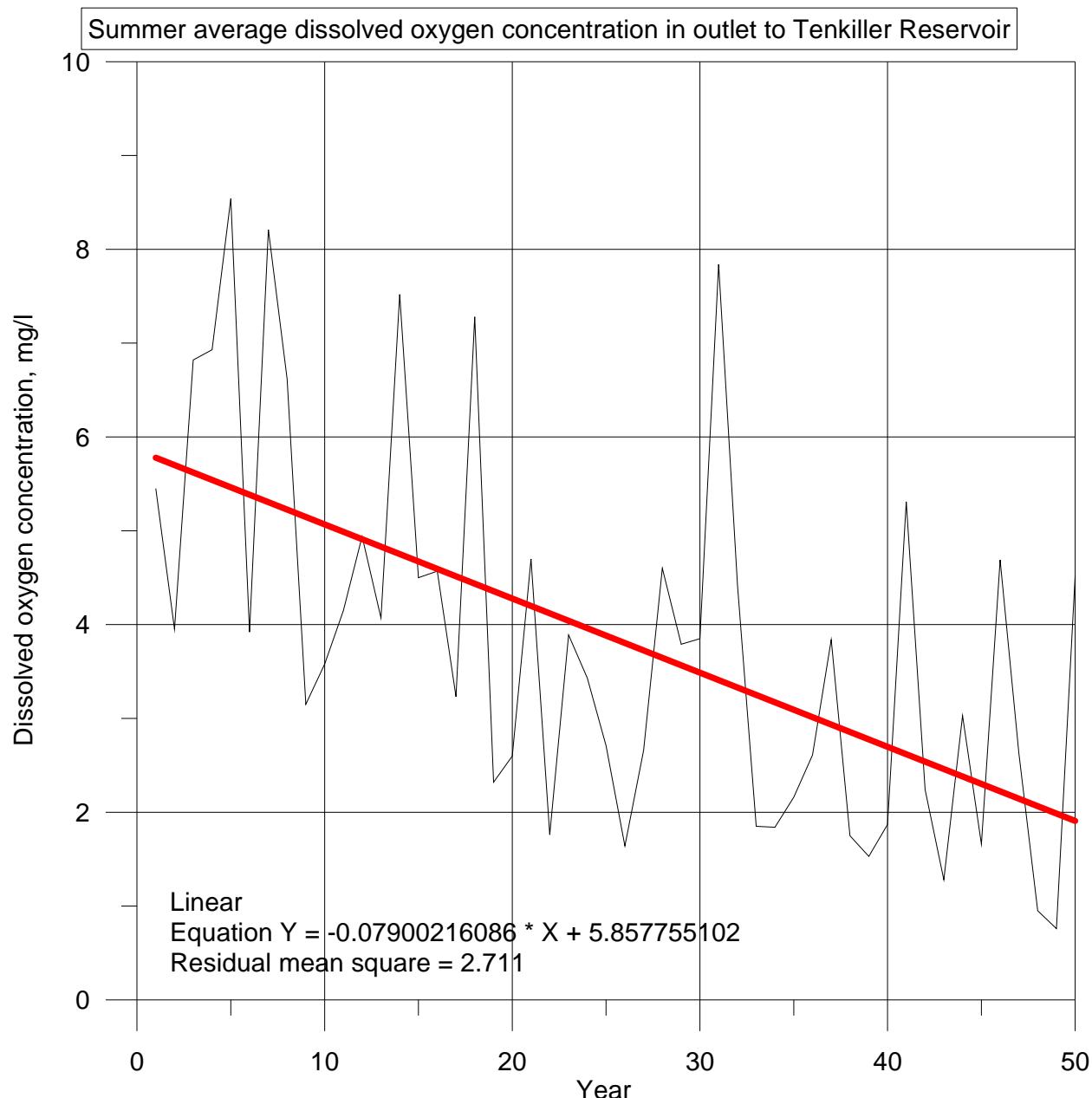
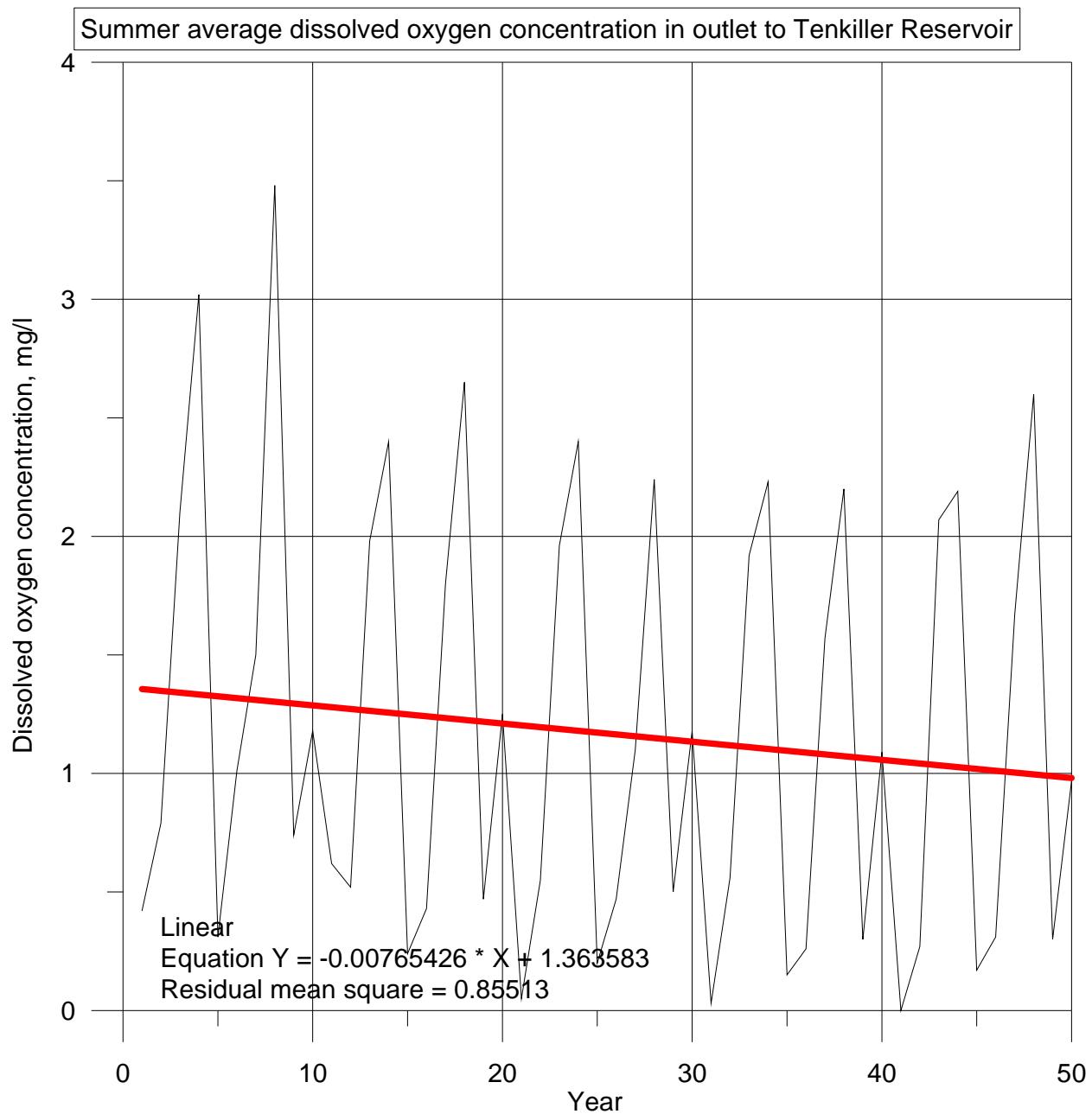


Figure 190. Historical scenario for summer outlet dissolved oxygen concentration each year for 50 years.



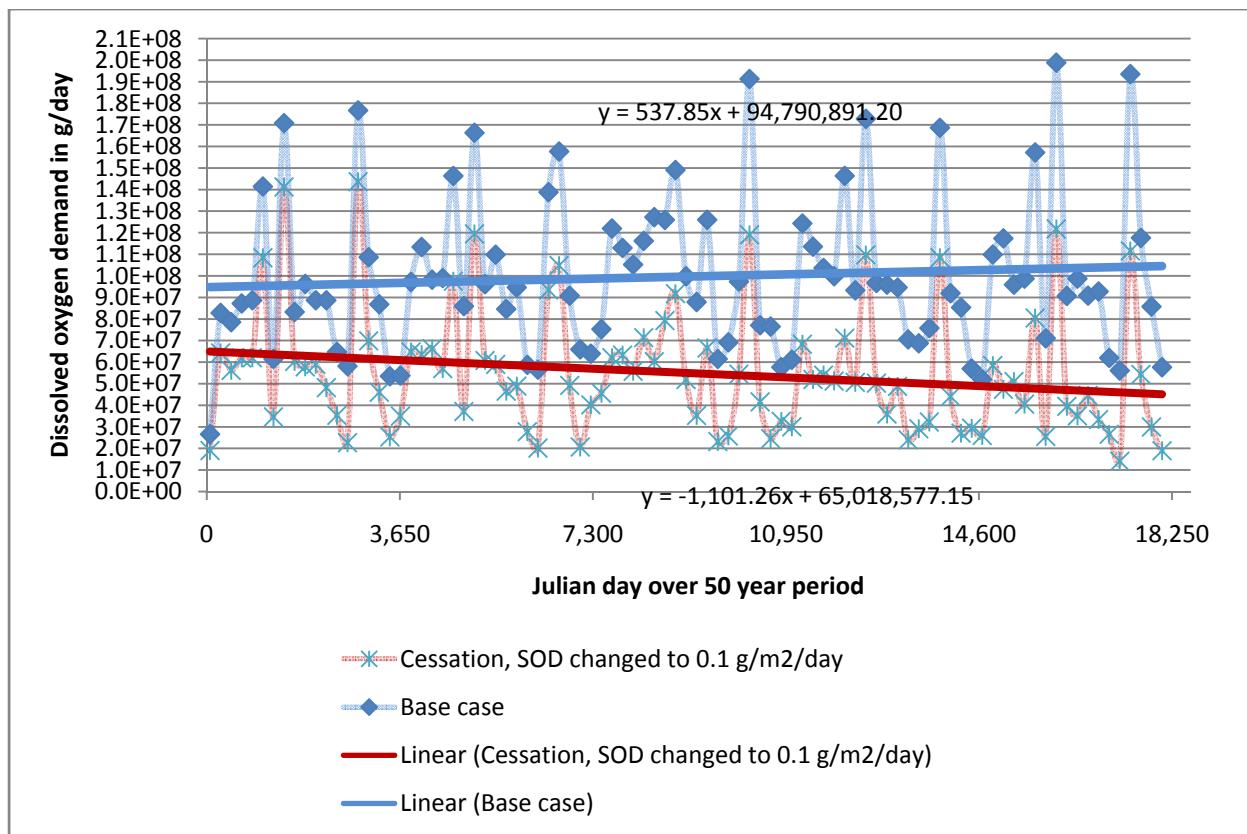


Figure 192. Difference between dissolved oxygen demand from zero order and first order sediment demand between base and cessation with SOD set to $0.1 \text{ g/m}^2/\text{d}$ scenarios including linear trend lines over the 50-year period.

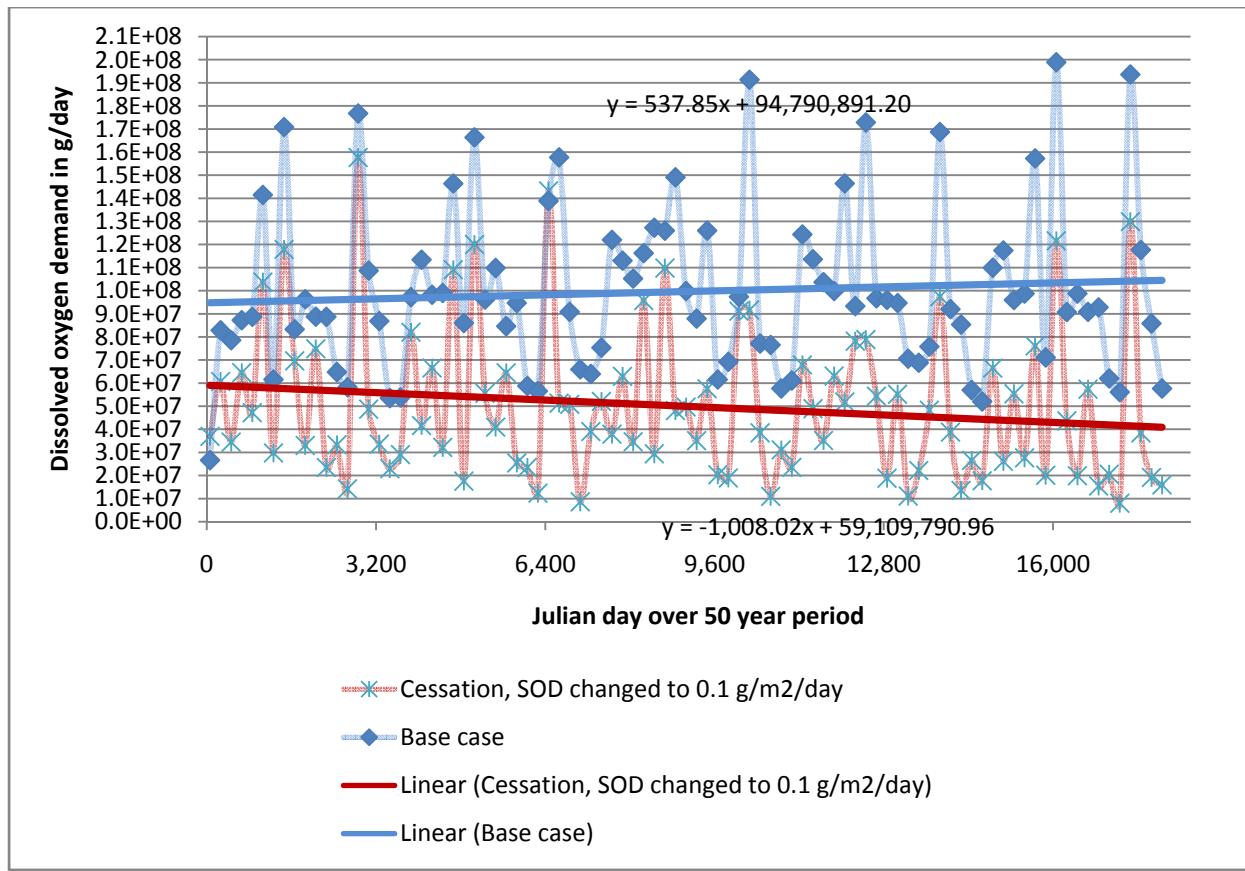


Figure 193. Dissolved oxygen demand from particulate and dissolved organic matter in the water column between base and cessation with SOD set to 0.1 g/m²/d scenarios including linear trend lines over the 50-year period.

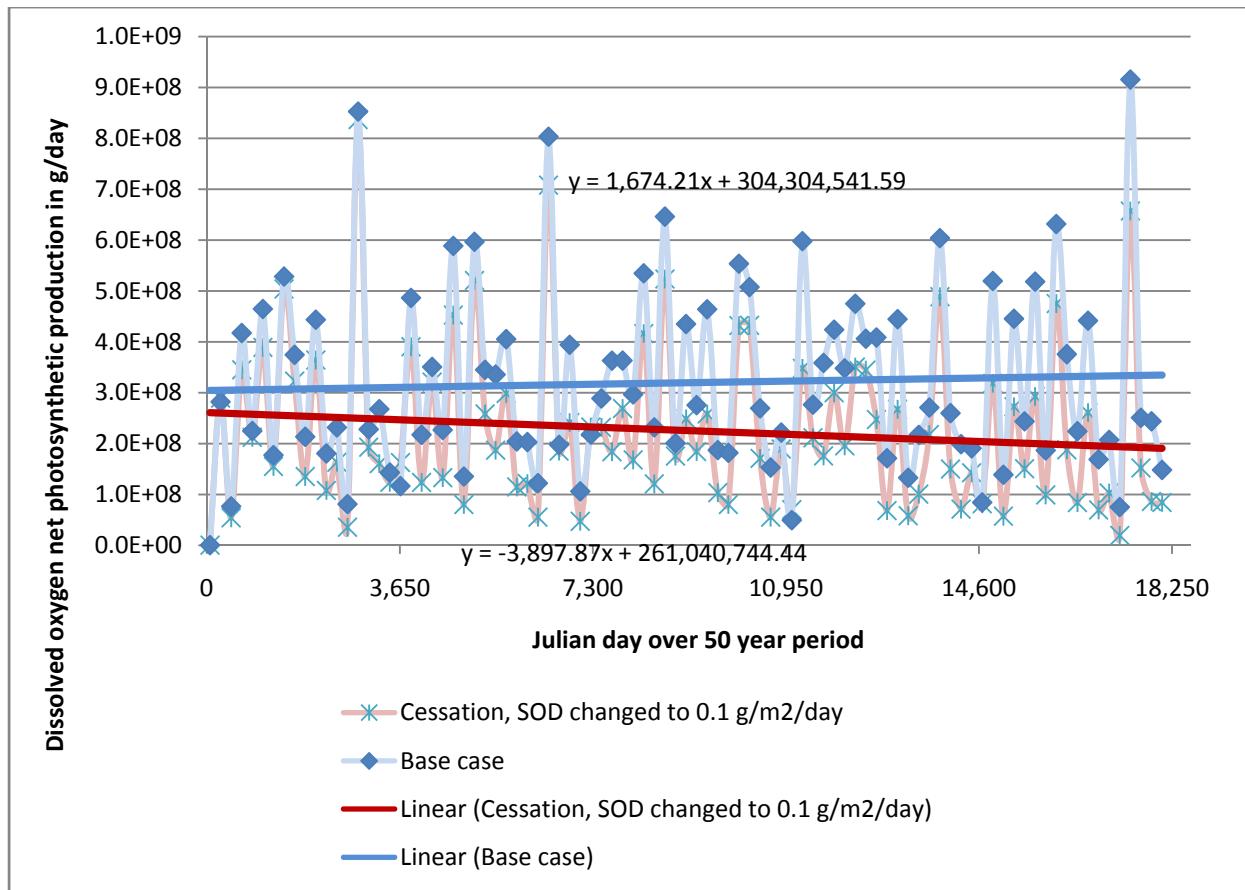


Figure 194. Dissolved oxygen net photosynthetic production from algae and periphyton between base and cessation scenarios with SOD set to 0.1 g/m²/d including linear trend lines over the 50-year period.

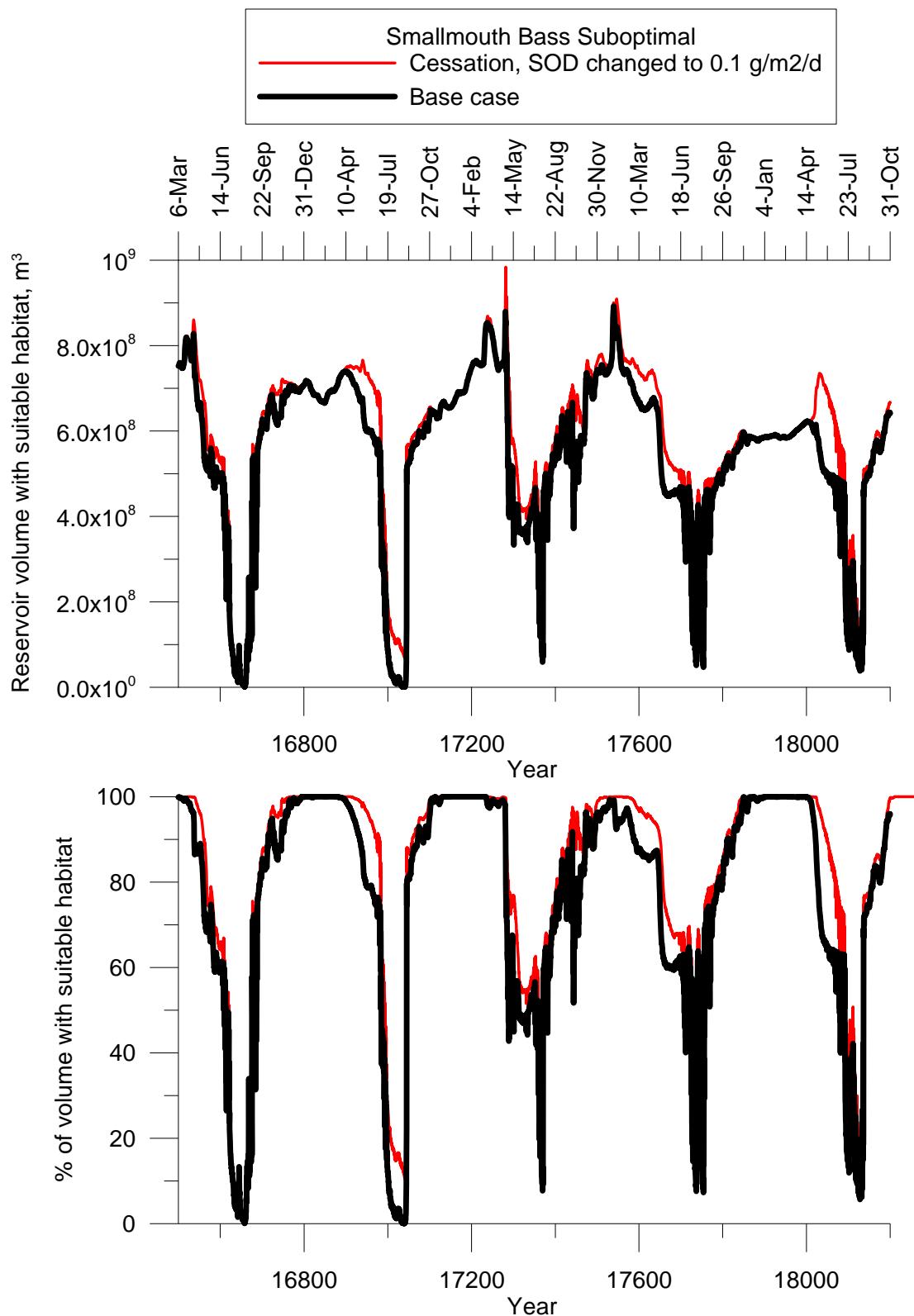


Figure 195. Smallmouth bass suboptimal habitat volume and fraction of volume over the last 5 years of the 50-year period.

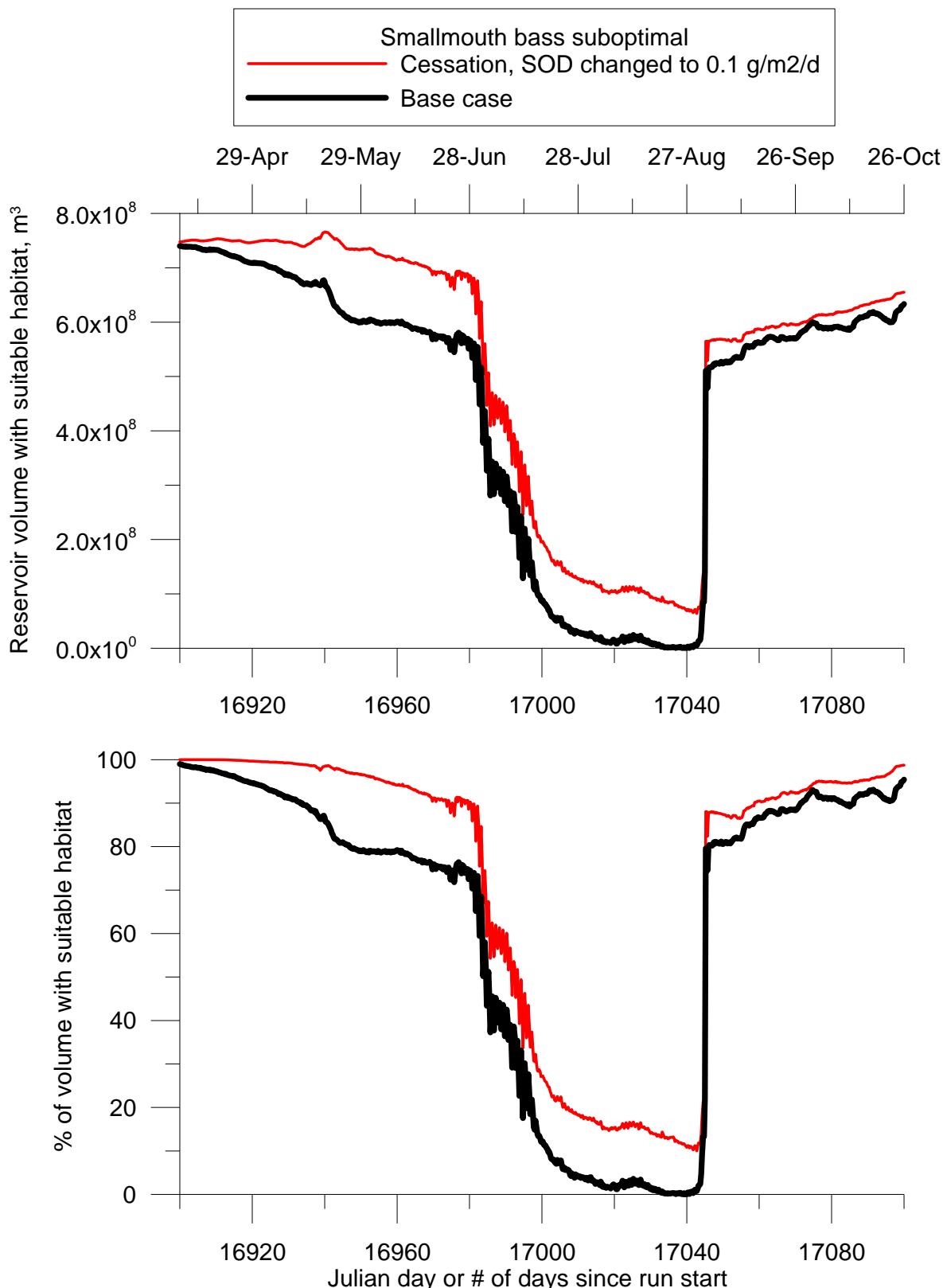


Figure 196. Smallmouth bass suboptimal habitat volume and fraction of volume over one of the last years of the 50-year period.

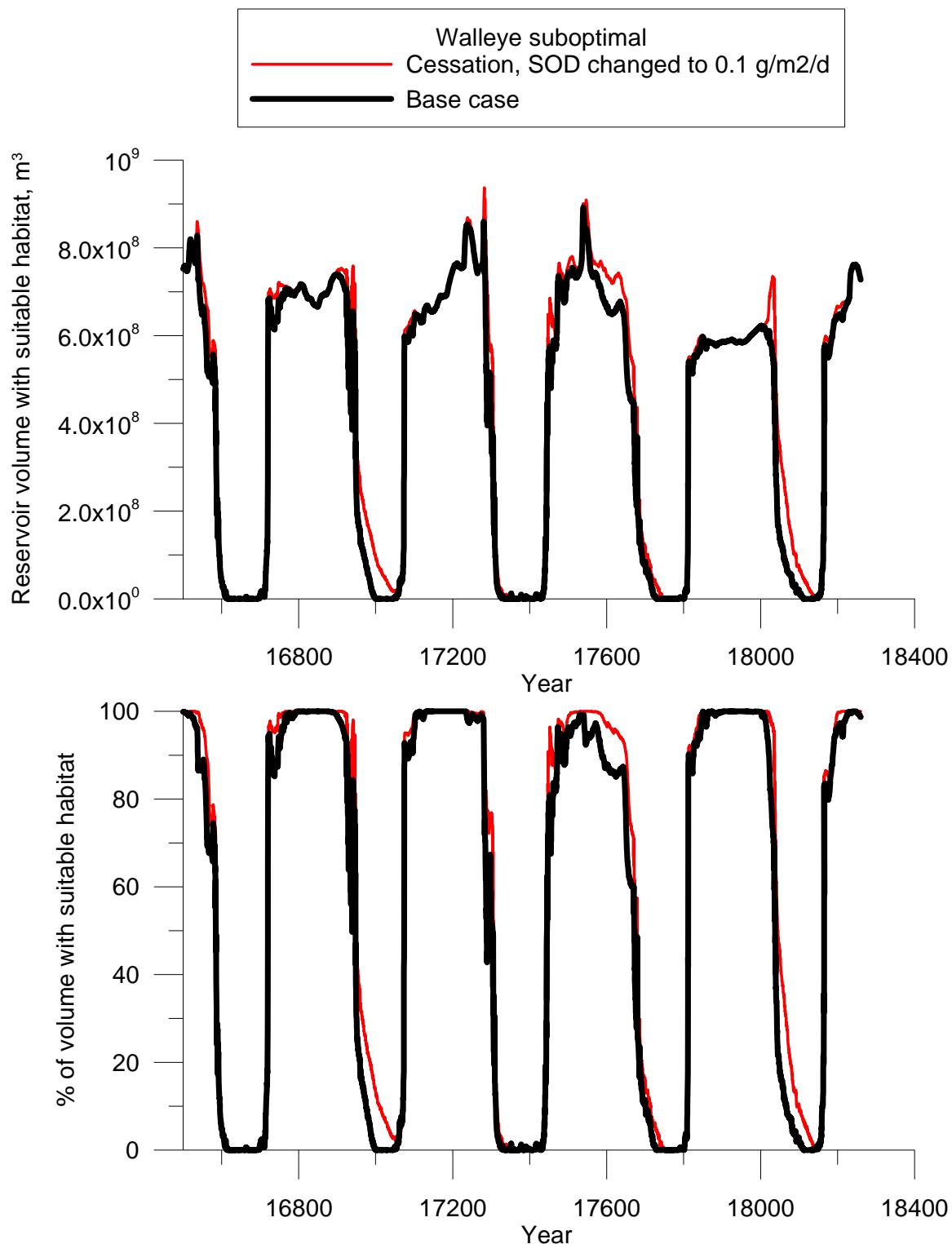


Figure 197. Walleye suboptimal habitat volume and fraction of volume over the last 5 years of the 50-year period.

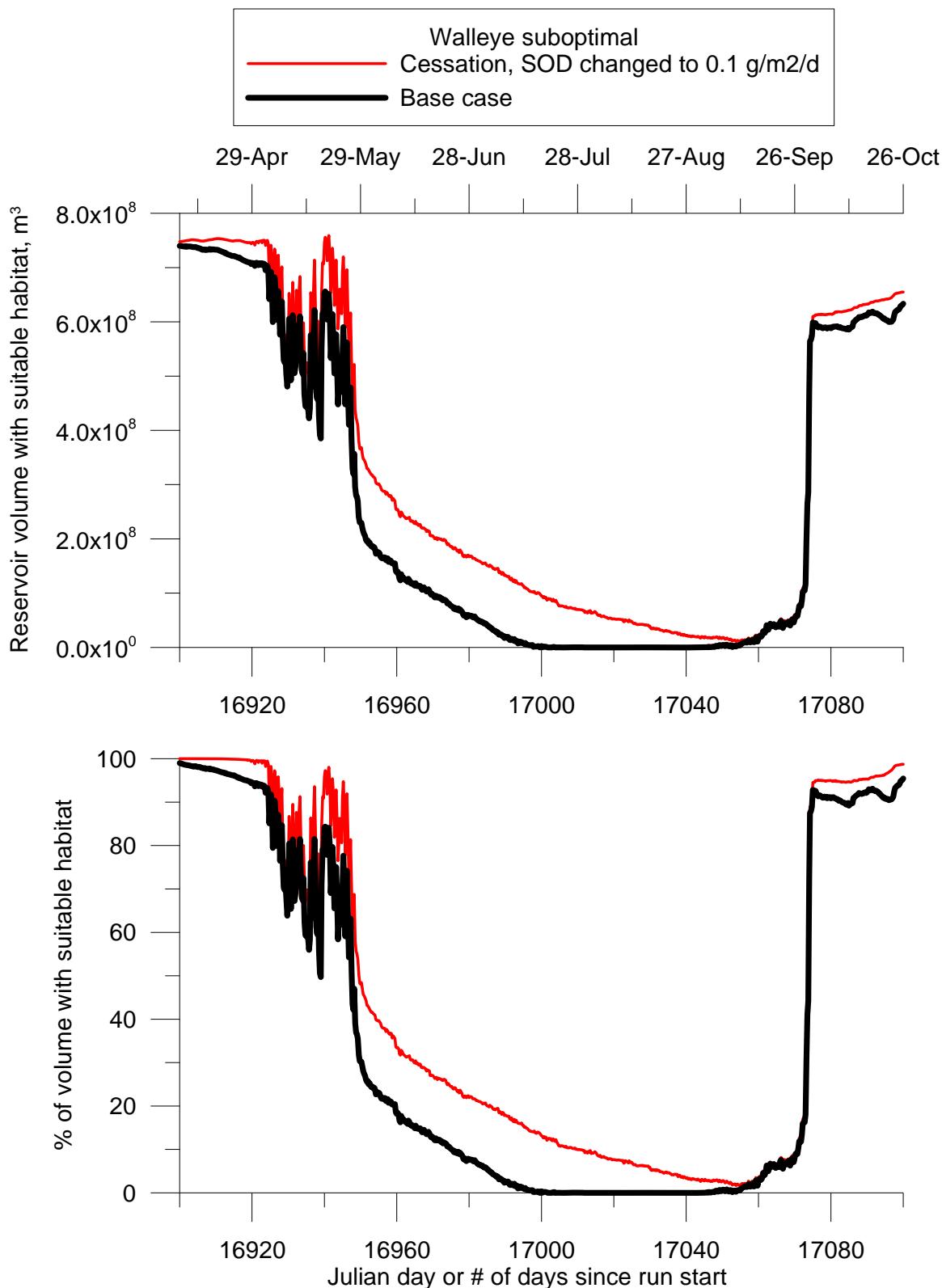


Figure 198. Walleye habitat volume and fraction of volume over one of the last years in the 50-year period.

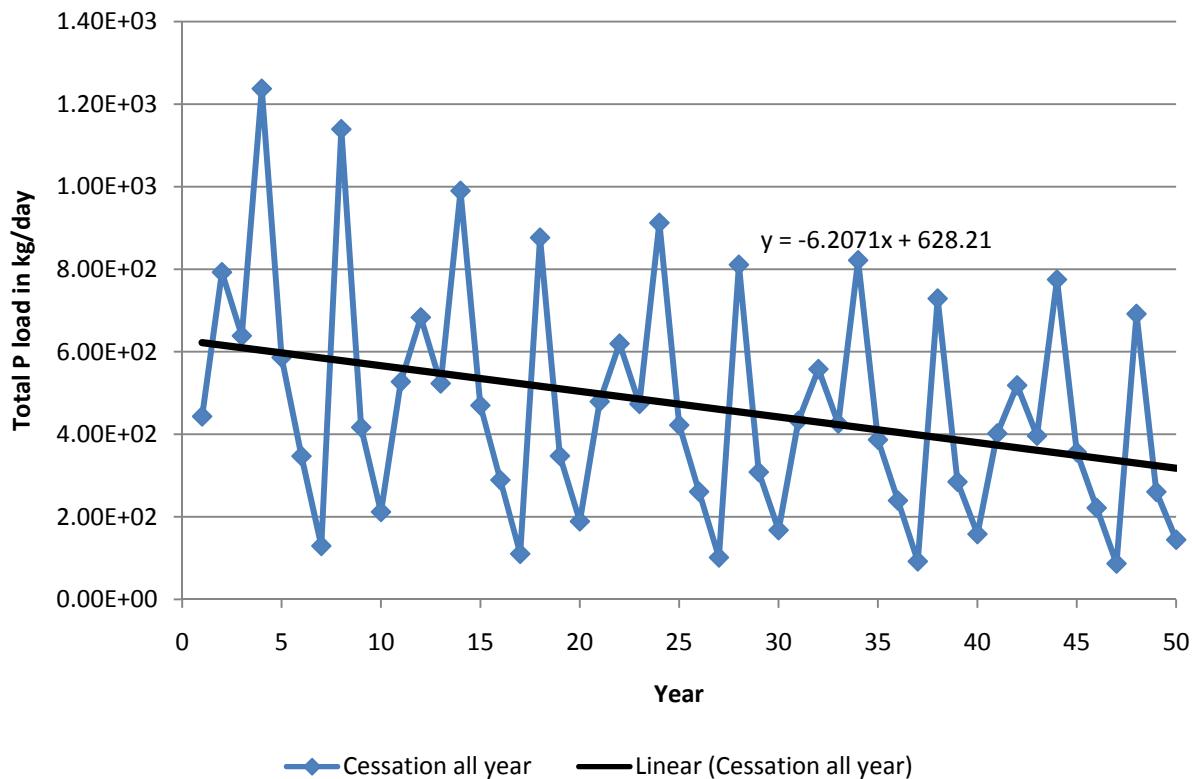


Figure 200. Yearly Total P inflow load to Tenkiller reservoir for the cessation scenario including linear trend line over 50-year period.

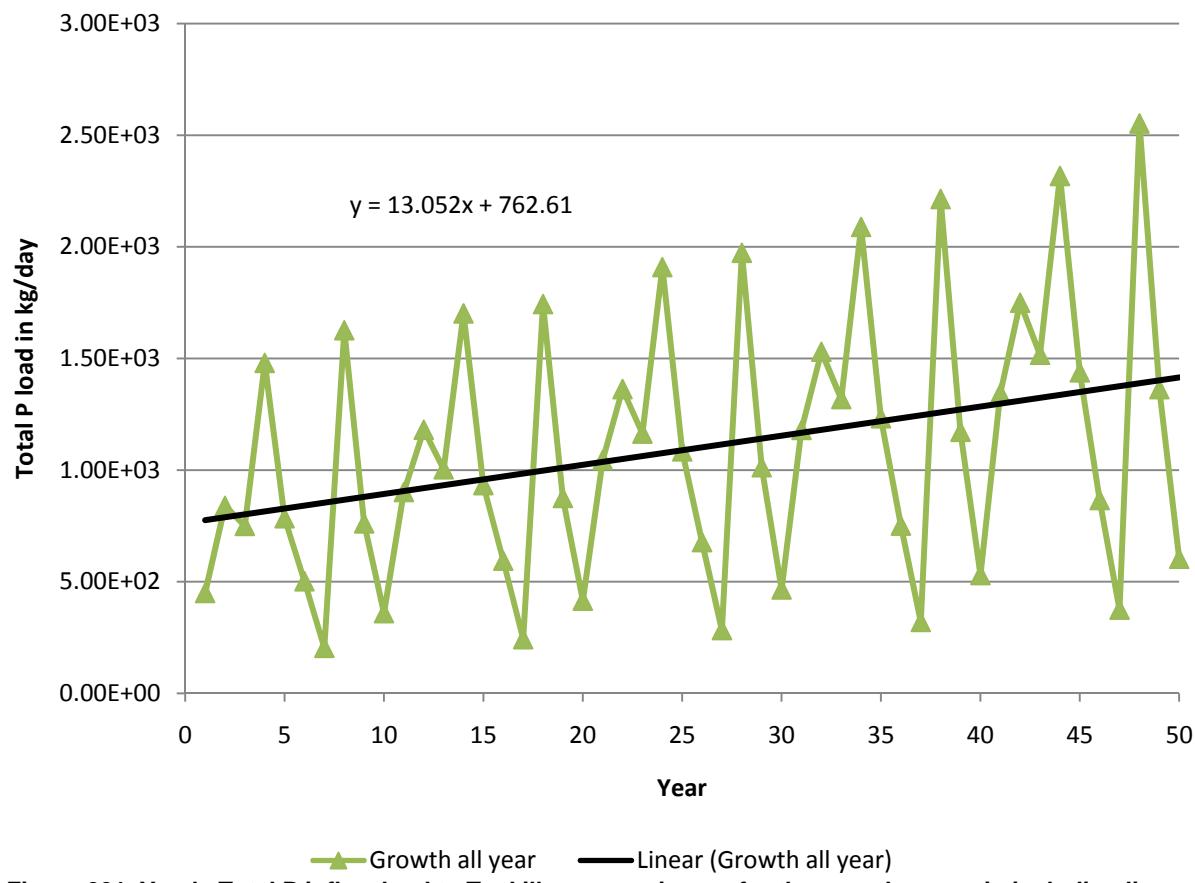


Figure 201. Yearly Total P inflow load to Tenkiller reservoir over for the growth scenario including linear trend line over 50-year period.

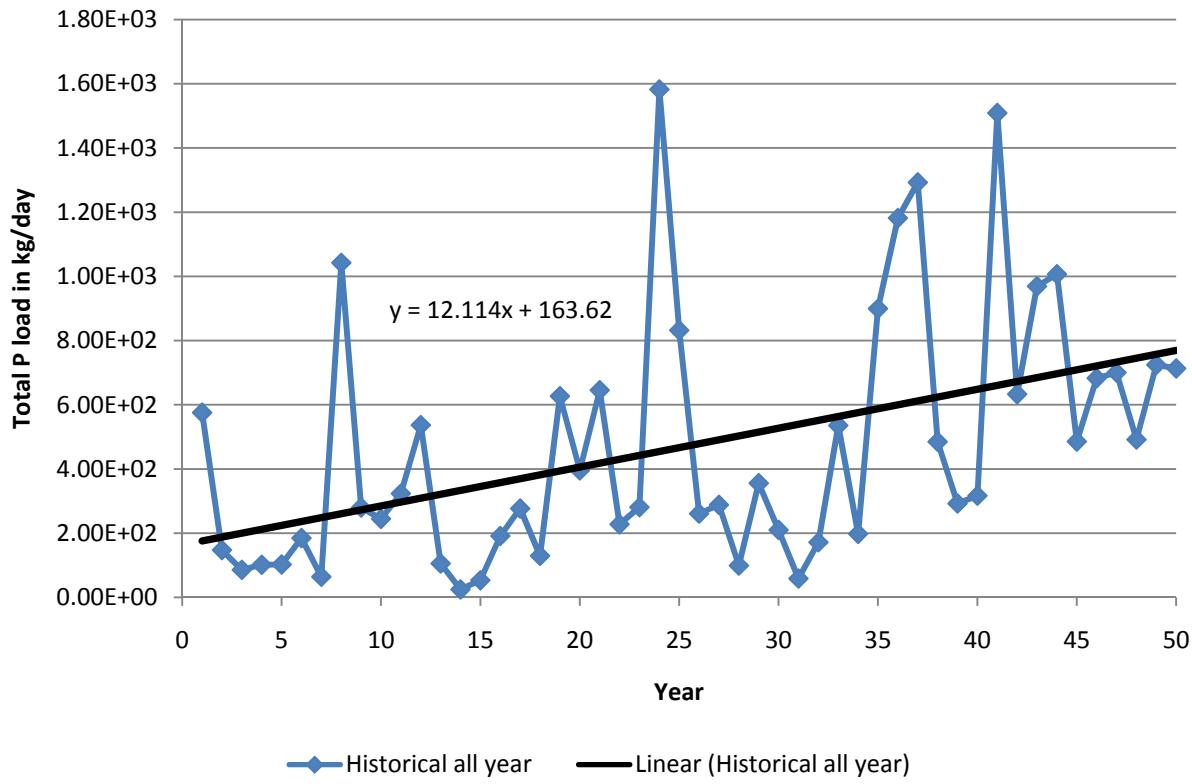


Figure 202. Yearly Total P inflow load to Tenkiller reservoir for the historical scenario including linear trend line over 50-year period.

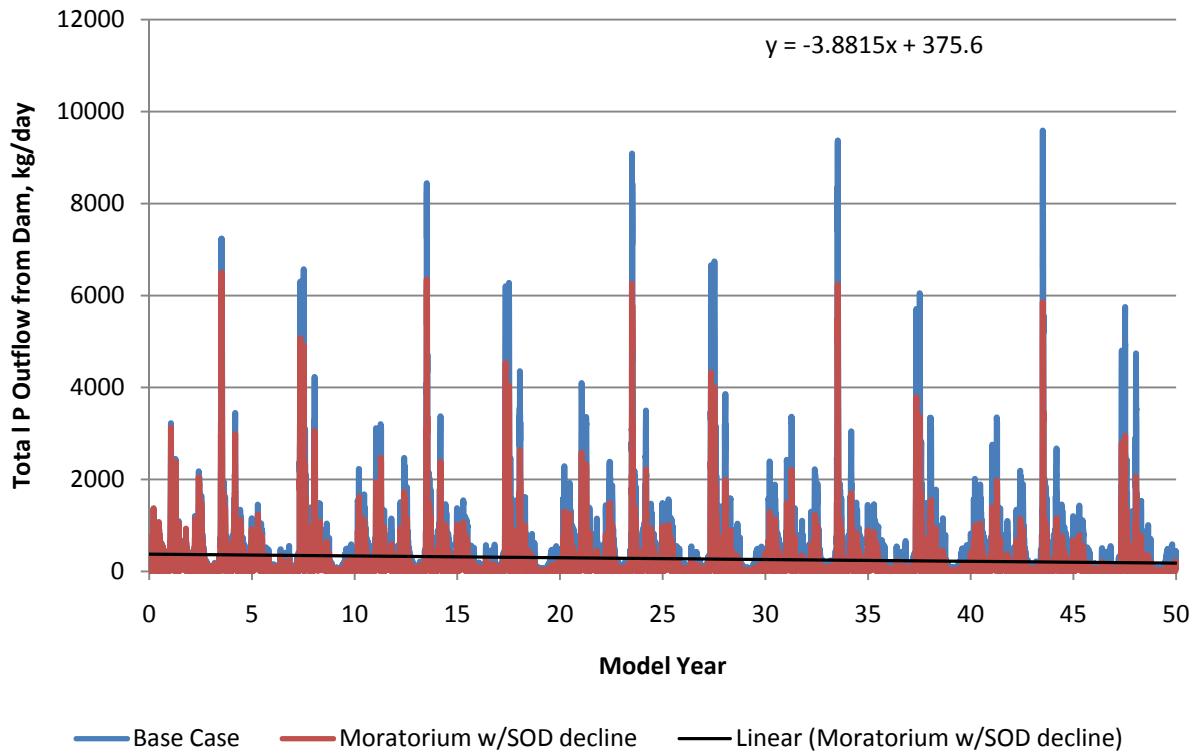


Figure 203. Total P outflow from Tenkiller reservoir for base and cessation scenarios, including linear cessation trend line over the 50-year period.

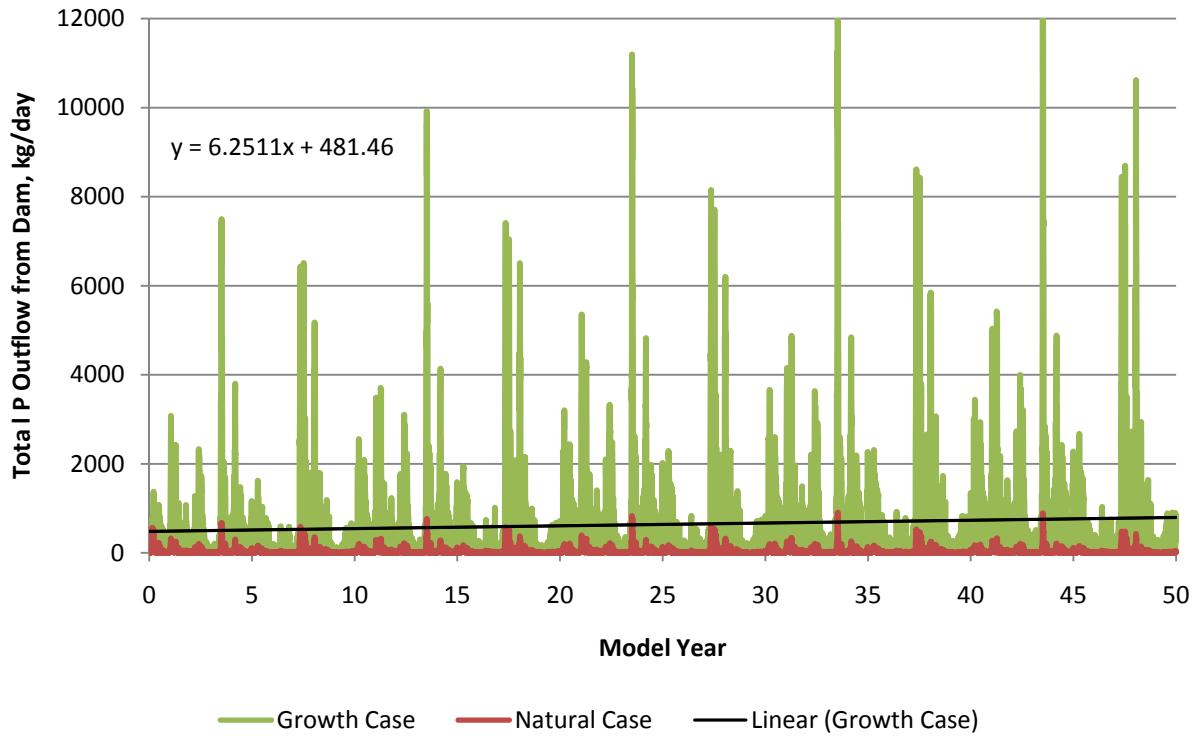


Figure 204. Total P outflow from Tenkiller reservoir for natural and growth scenarios, including linear growth trend line over the 50-year period.

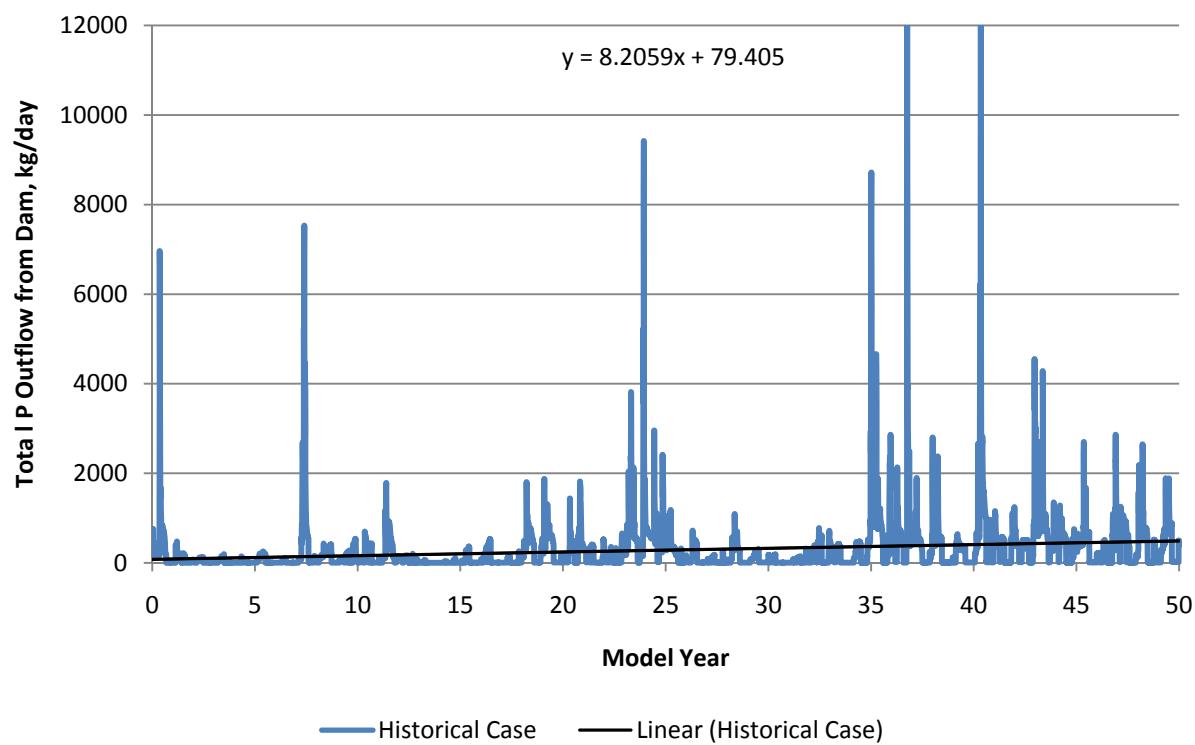


Figure 205. Total P outflow from Tenkiller reservoir for historical case, including linear historical trend line over the 50-year period.

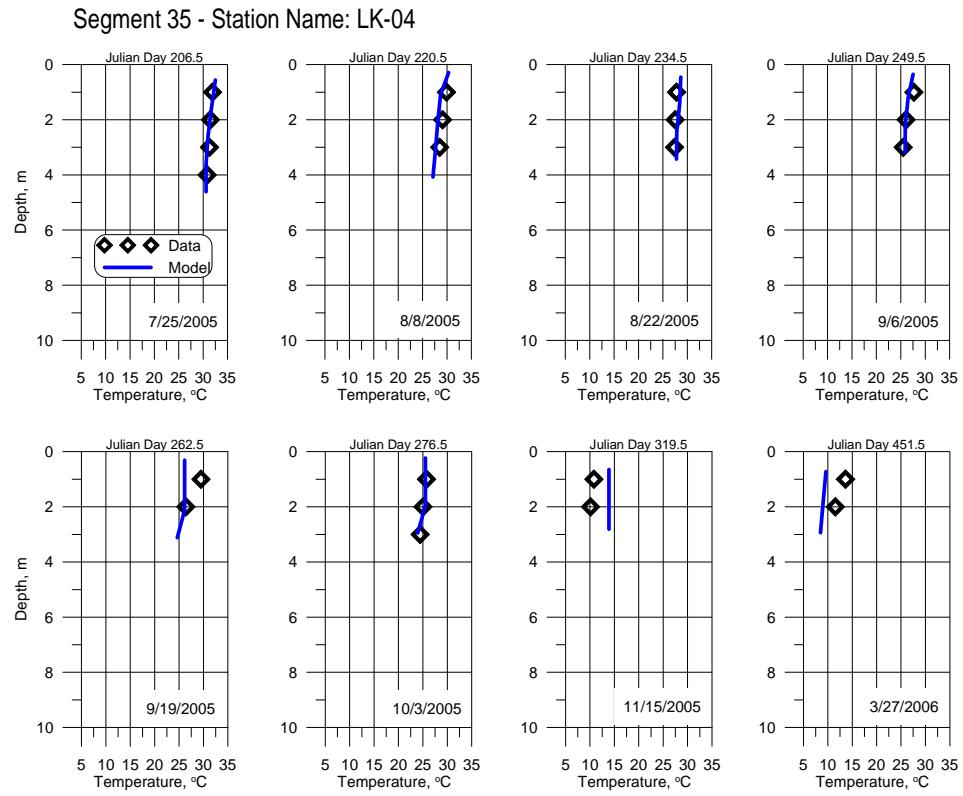
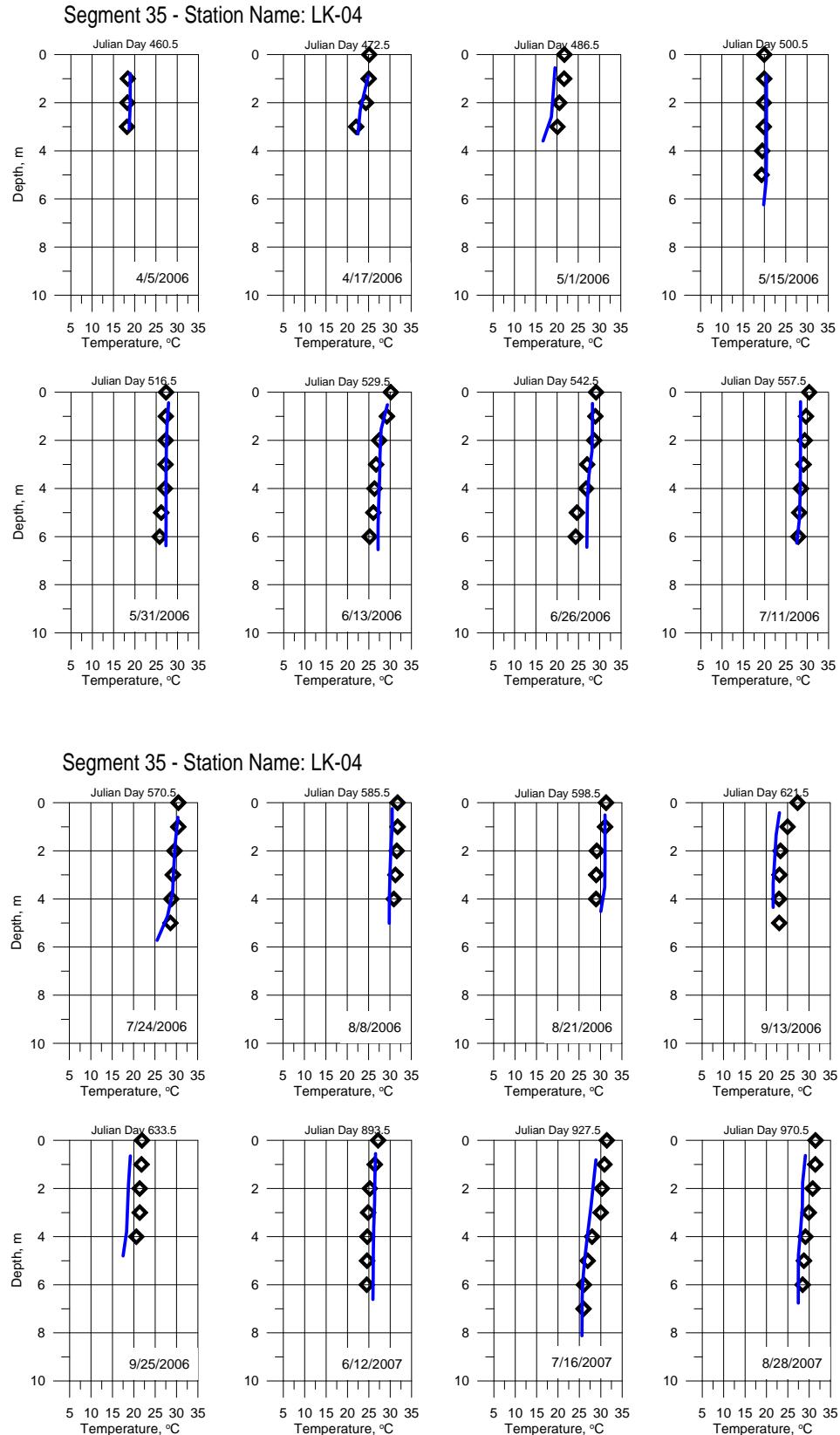
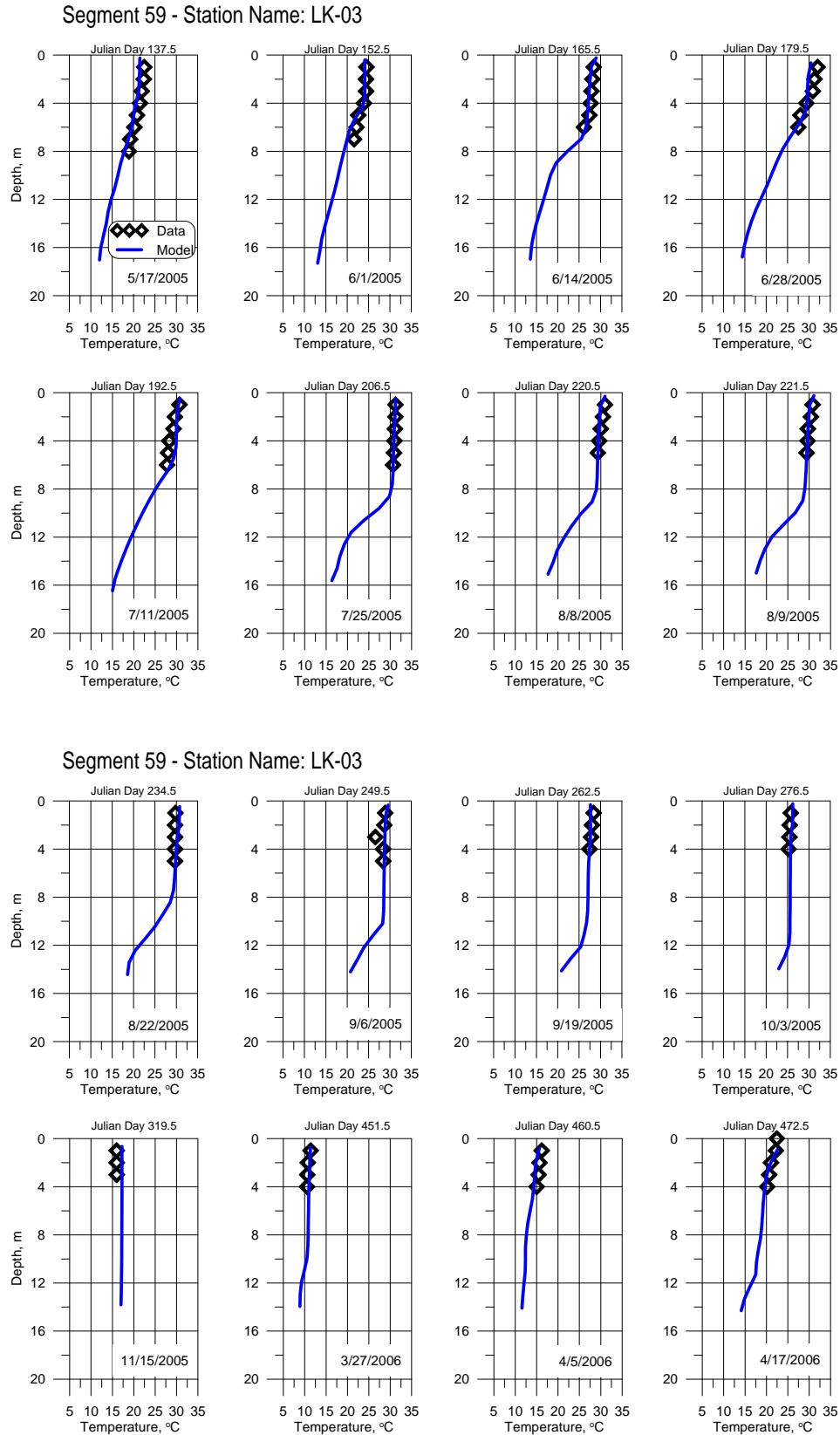
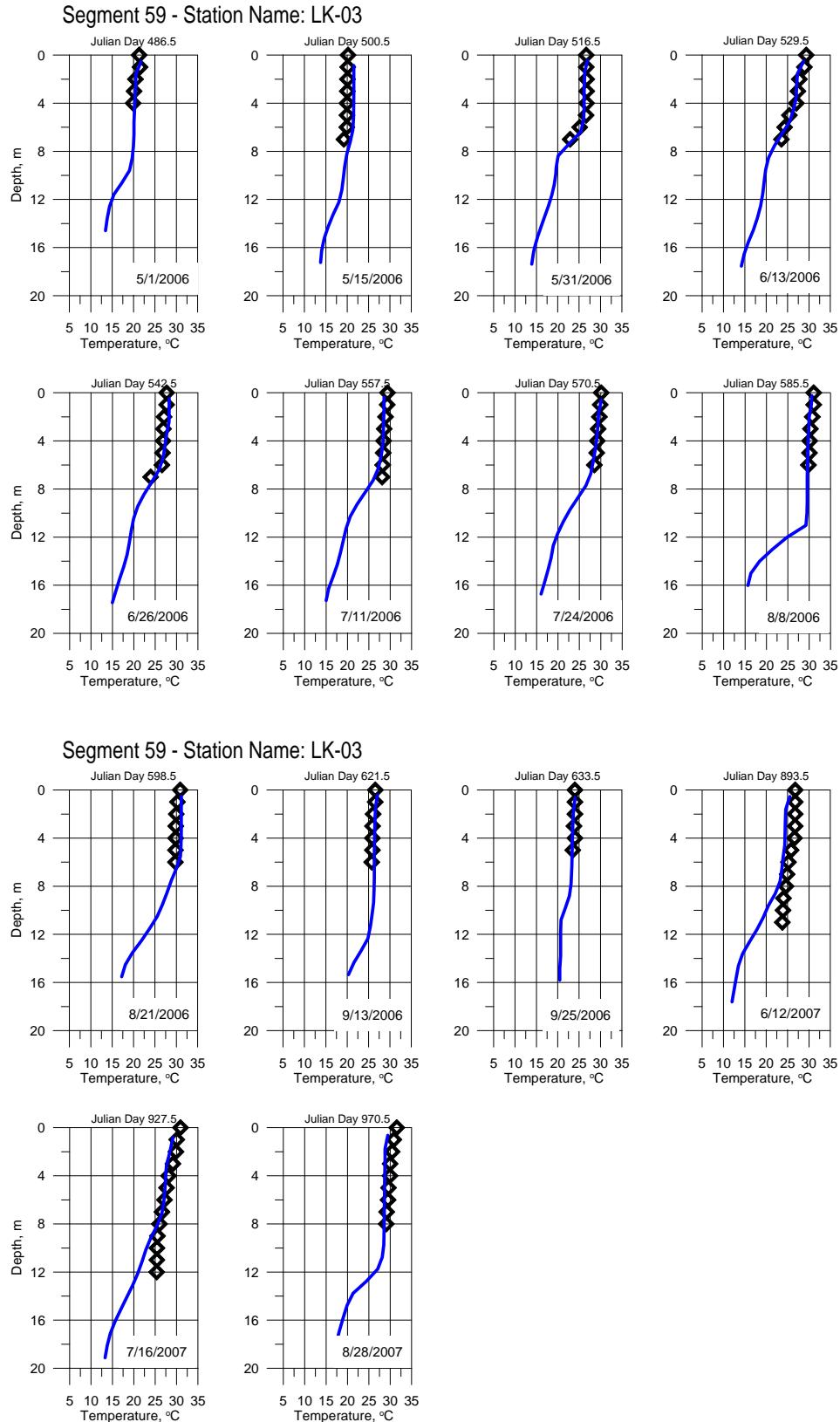


Figure 212. Temperature profiles segment 35 Part 1.

**Figure 213. Temperature profiles segment 35 Parts 2 & 3.**

**Figure 214. Temperature profiles segment 59 Parts 1 & 2.**

**Figure 215. Temperature profiles segment 59 Parts 3 & 4.**

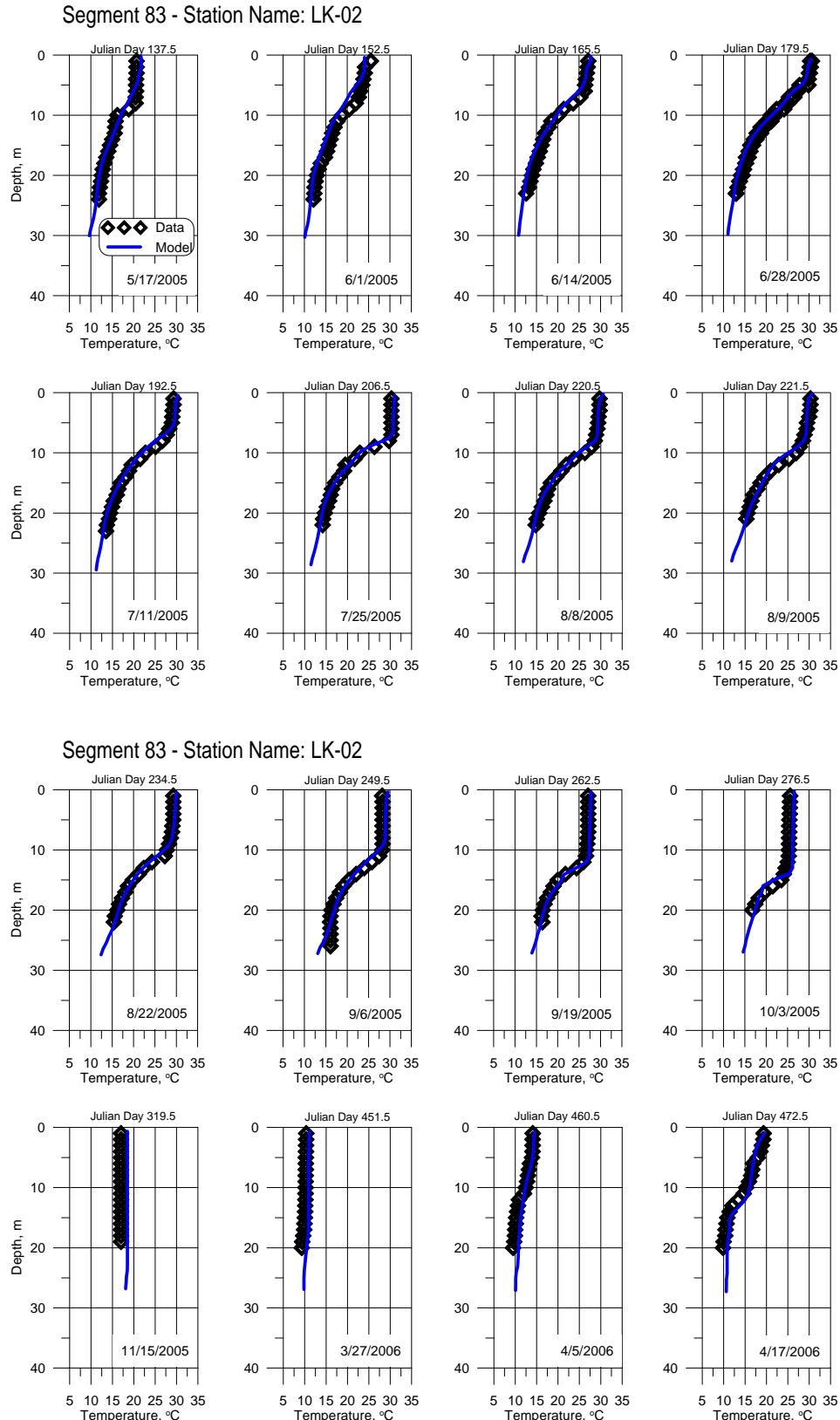


Figure 216. Temperature profiles segment 83 Parts 1 & 2.

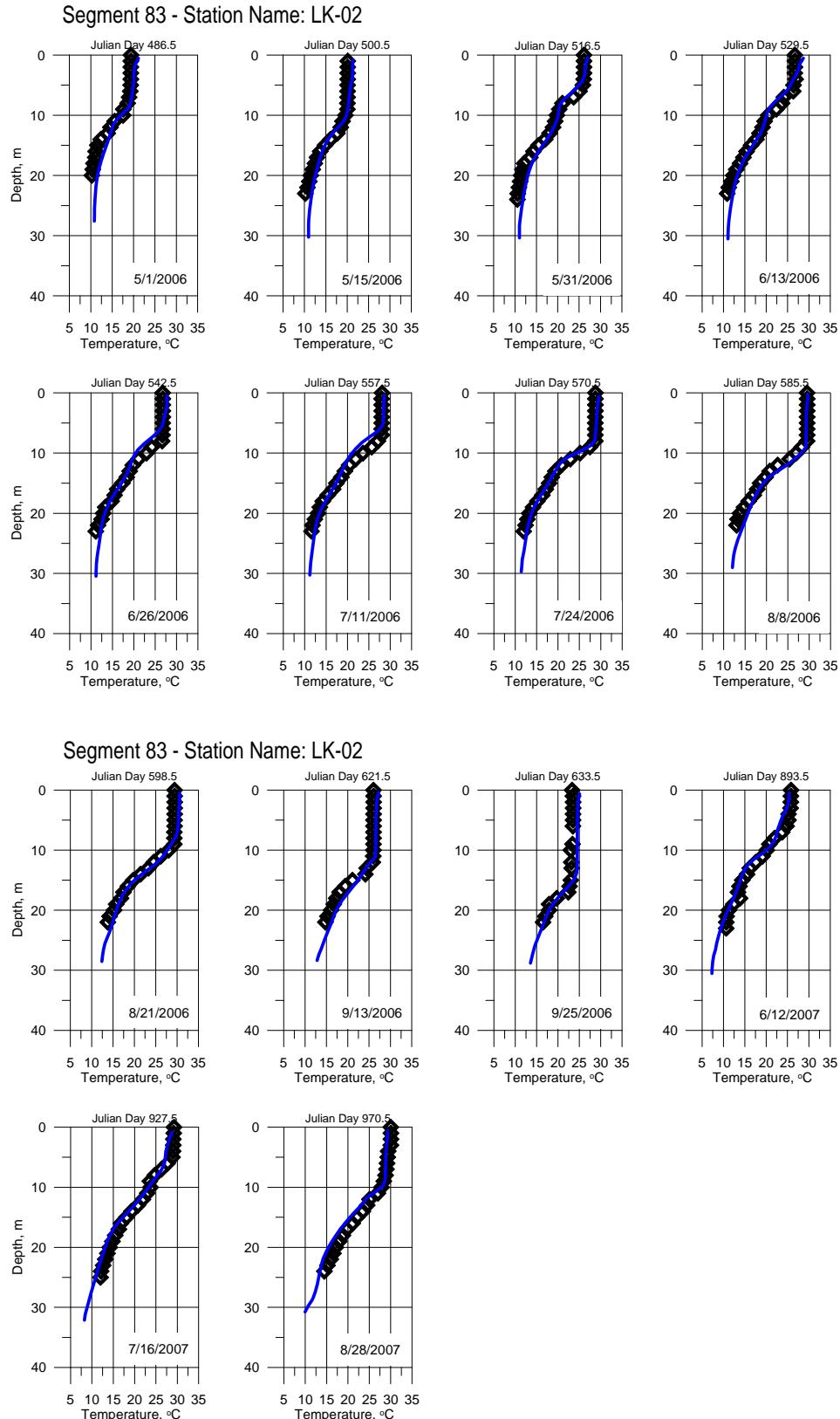


Figure 217. Temperature profiles segment 83 Parts 3 & 4.

Segment 109 - Station Name: LK-05

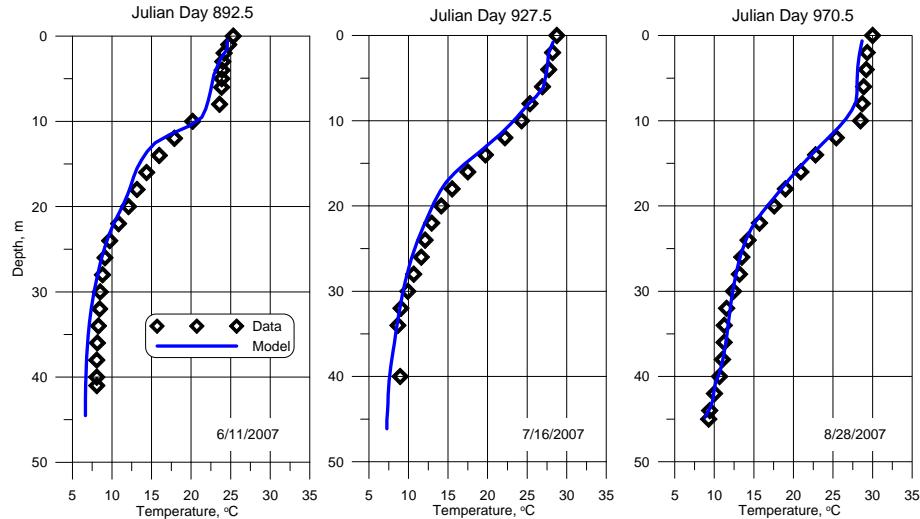


Figure 218. Temperature profiles segment 109.

Segment 199 - Station Name: LK-01

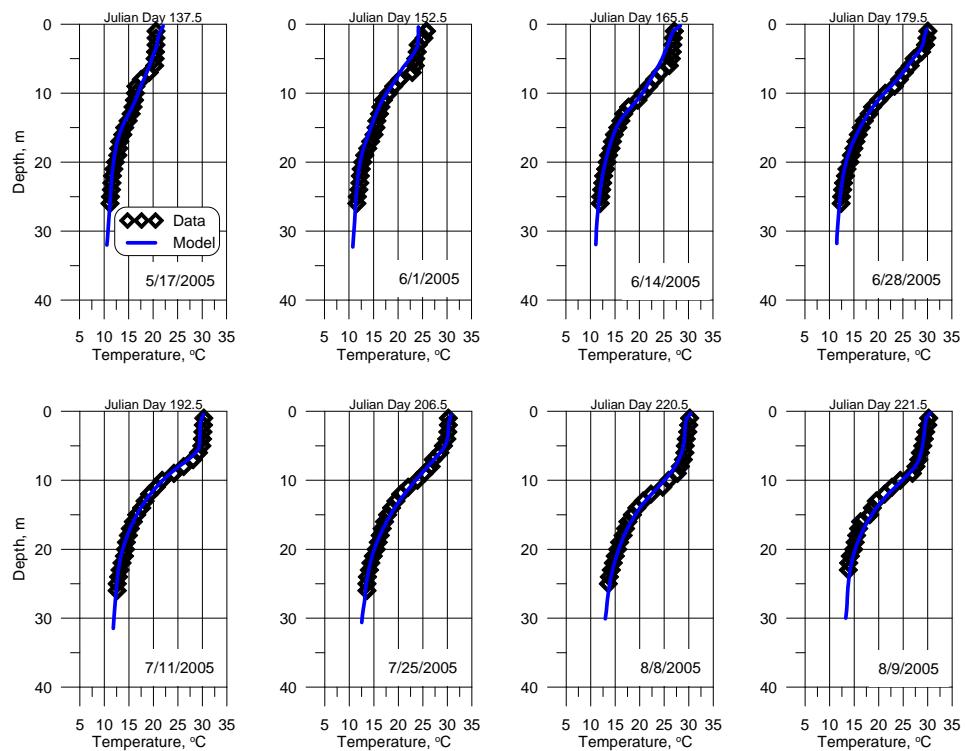


Figure 219. Temperature profiles segment 199 Part 1.

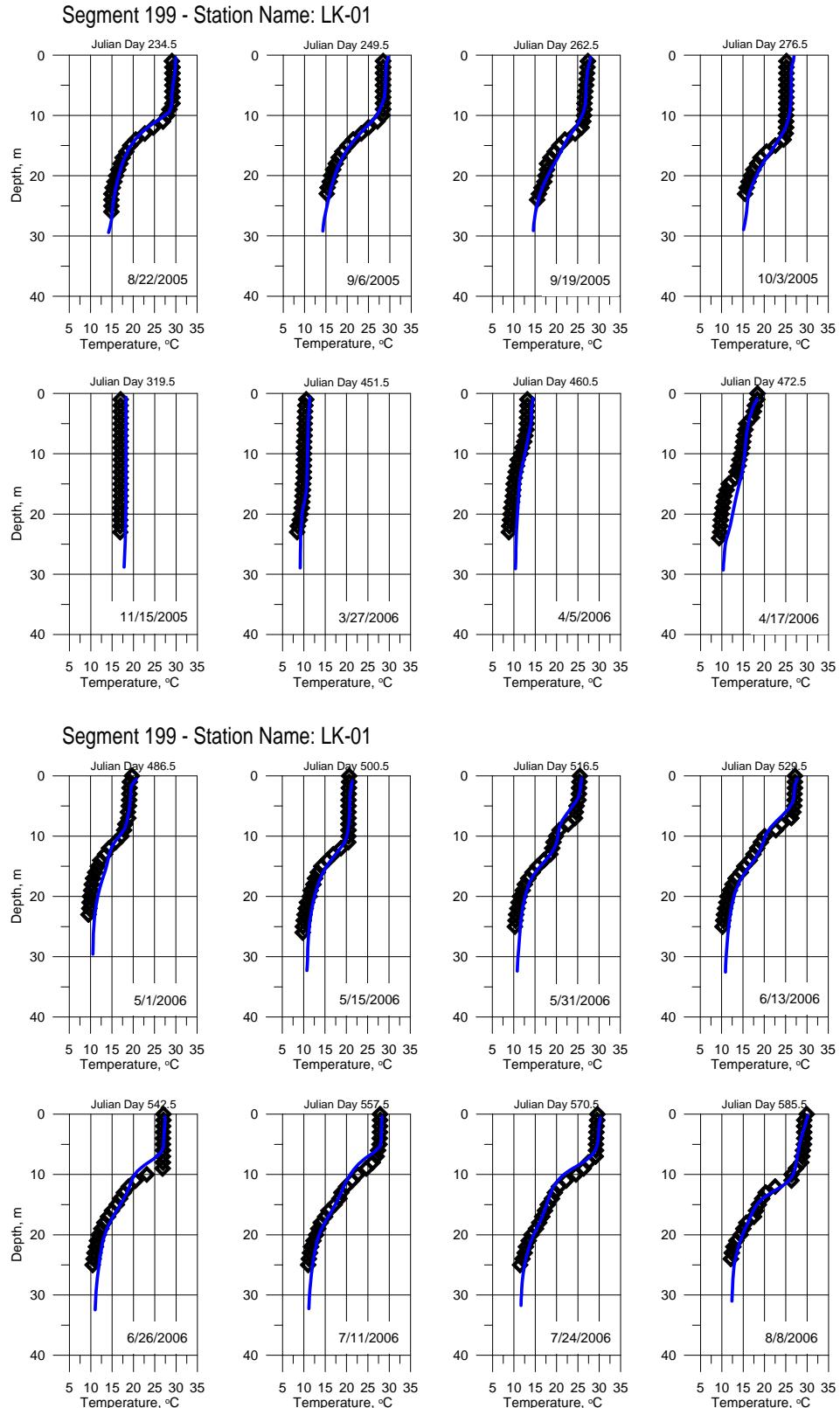


Figure 220. Temperature profiles segment 199 Parts 2 & 3.

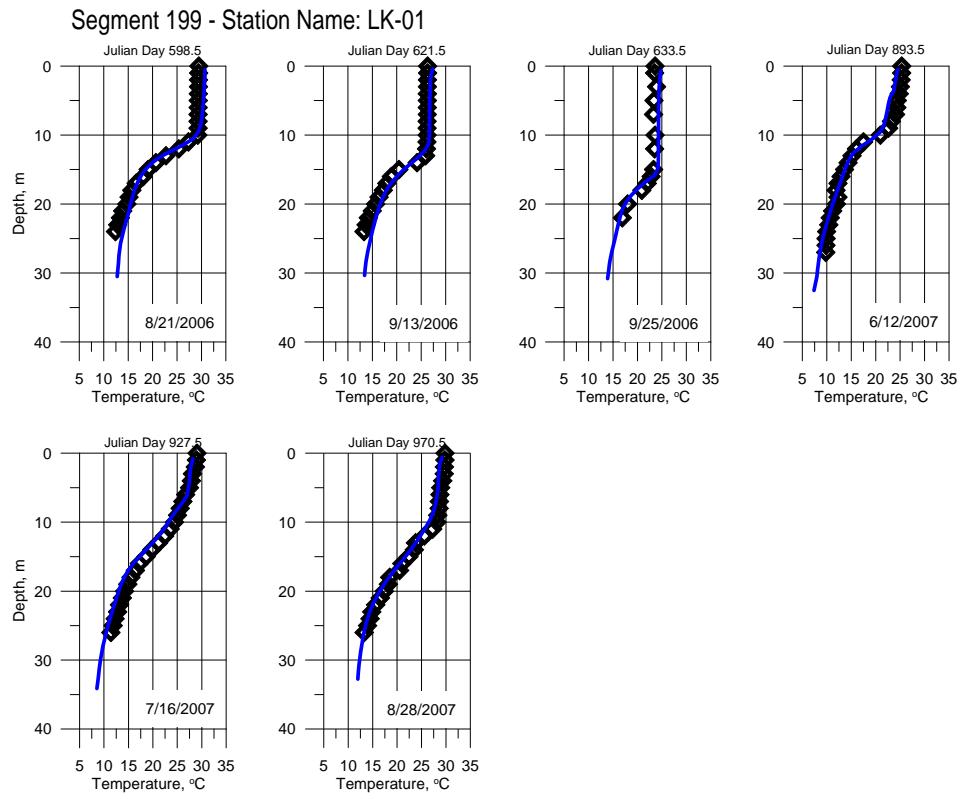


Figure 221. Temperature profiles segment 199 Part 4.

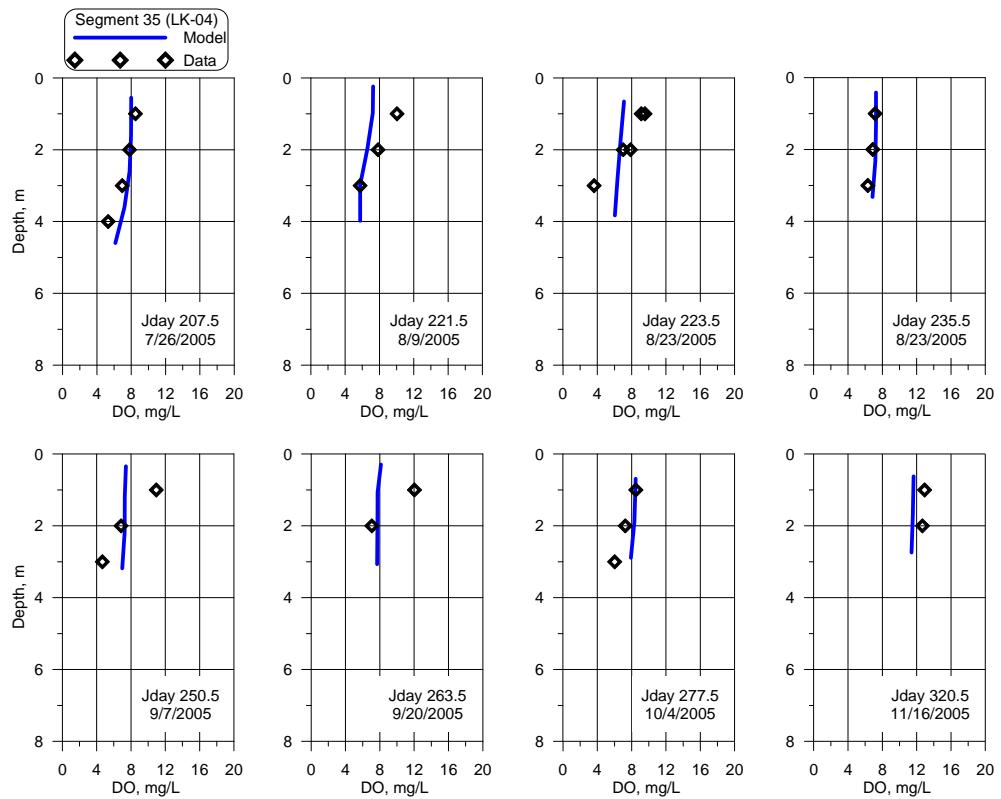
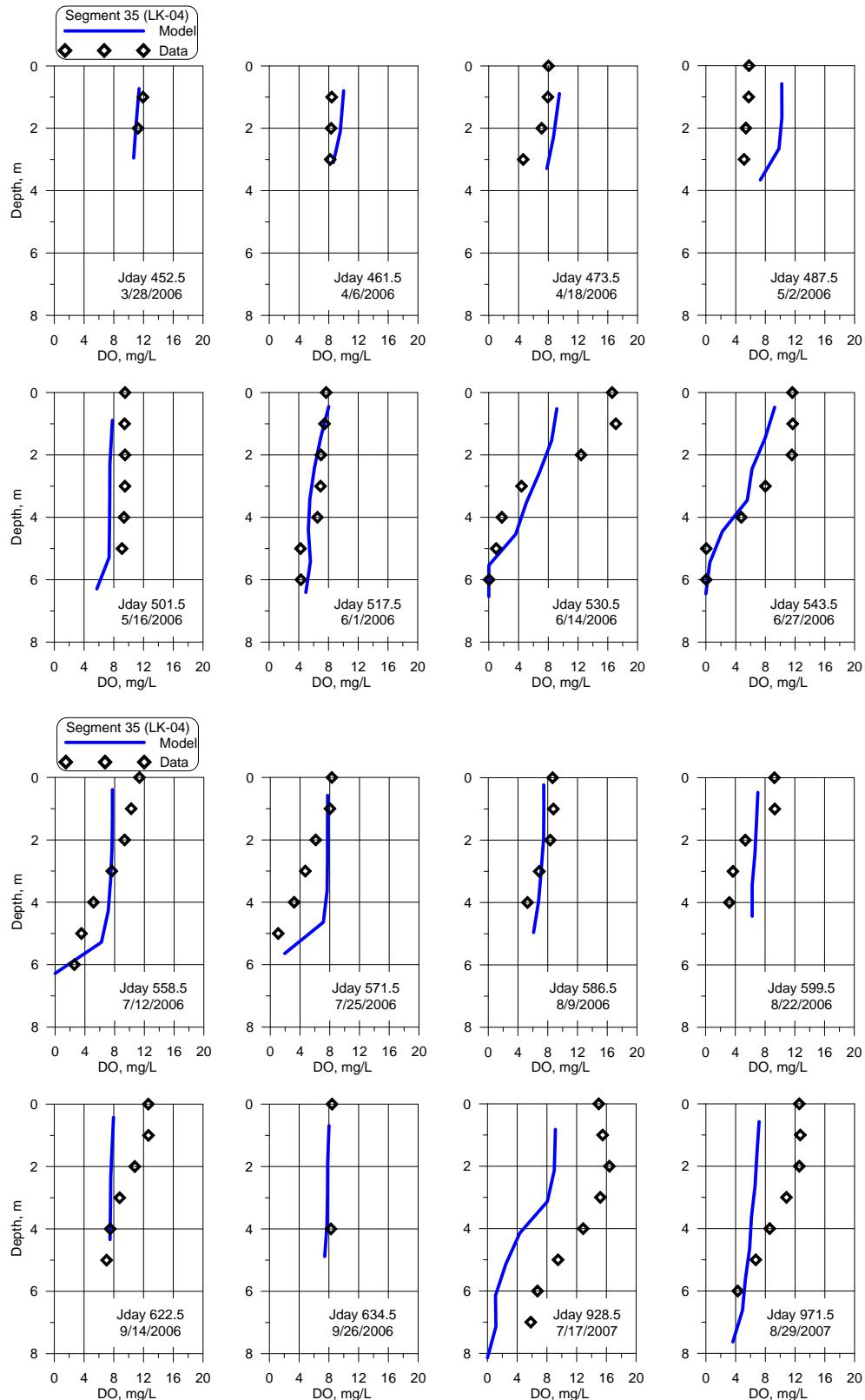


Figure 222. Dissolved oxygen profiles segment 35 Part 1.

**Figure 223. Dissolved oxygen profiles segment 35 Parts 2 & 3.**

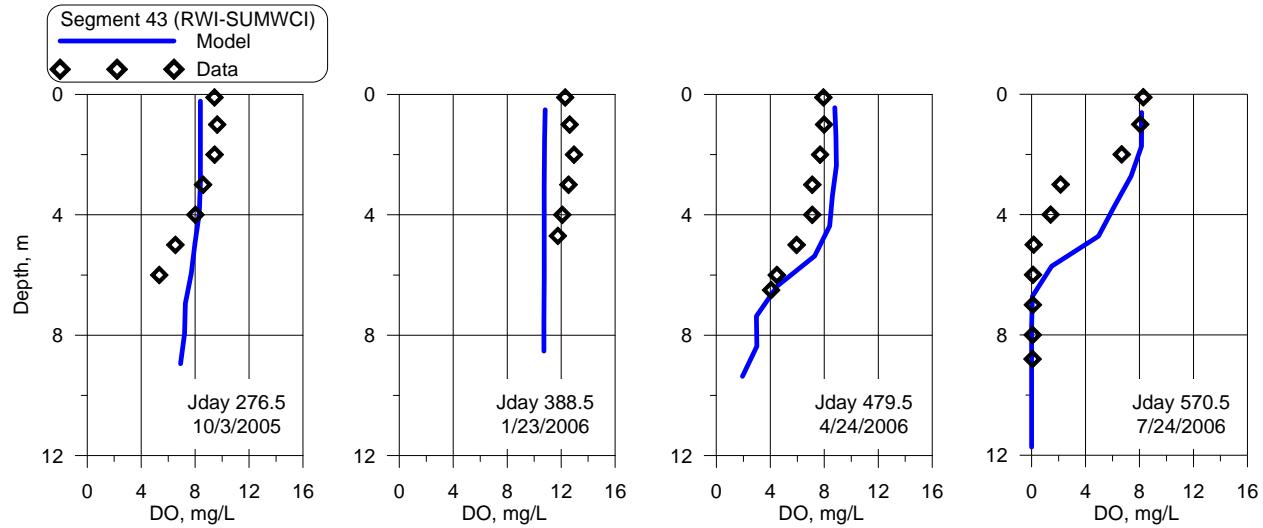


Figure 224. Dissolved oxygen profiles segment 43.

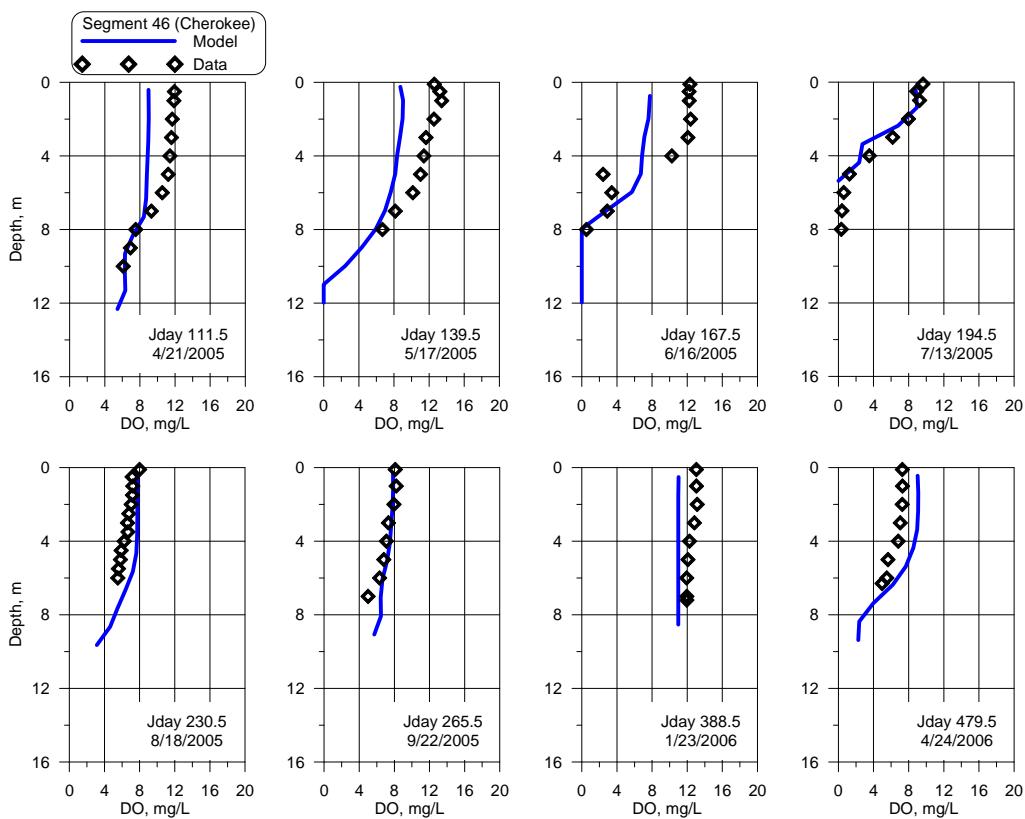


Figure 225. Dissolved oxygen profiles segment 46.

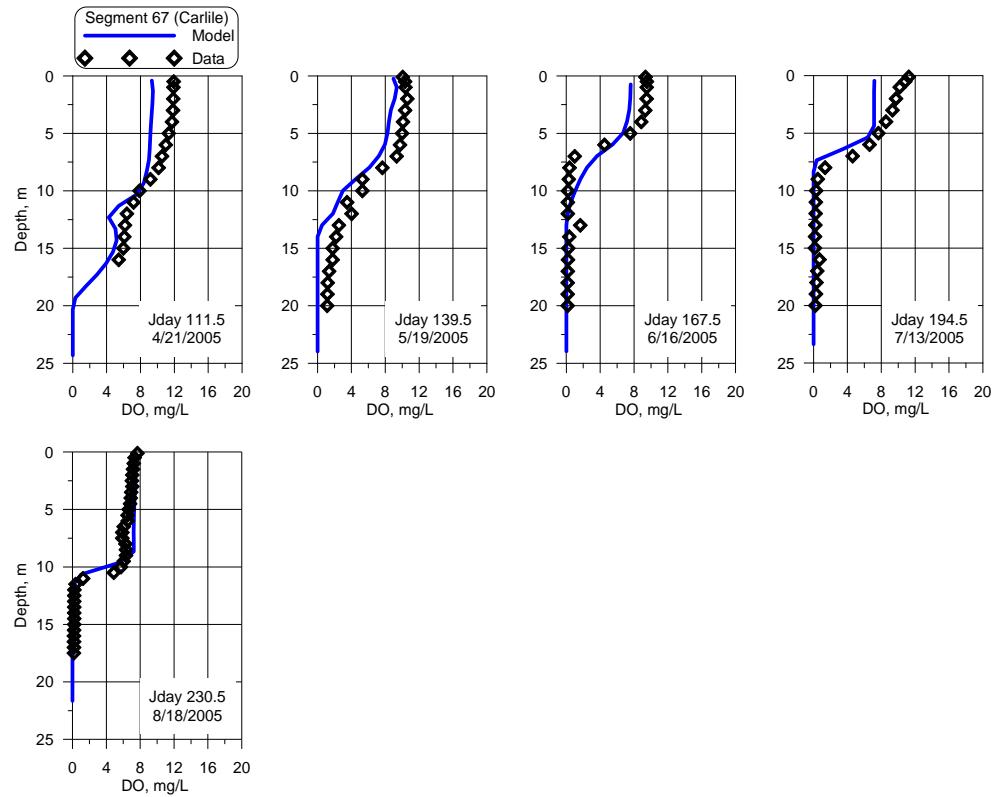


Figure 226. Dissolved oxygen profiles segment 67.

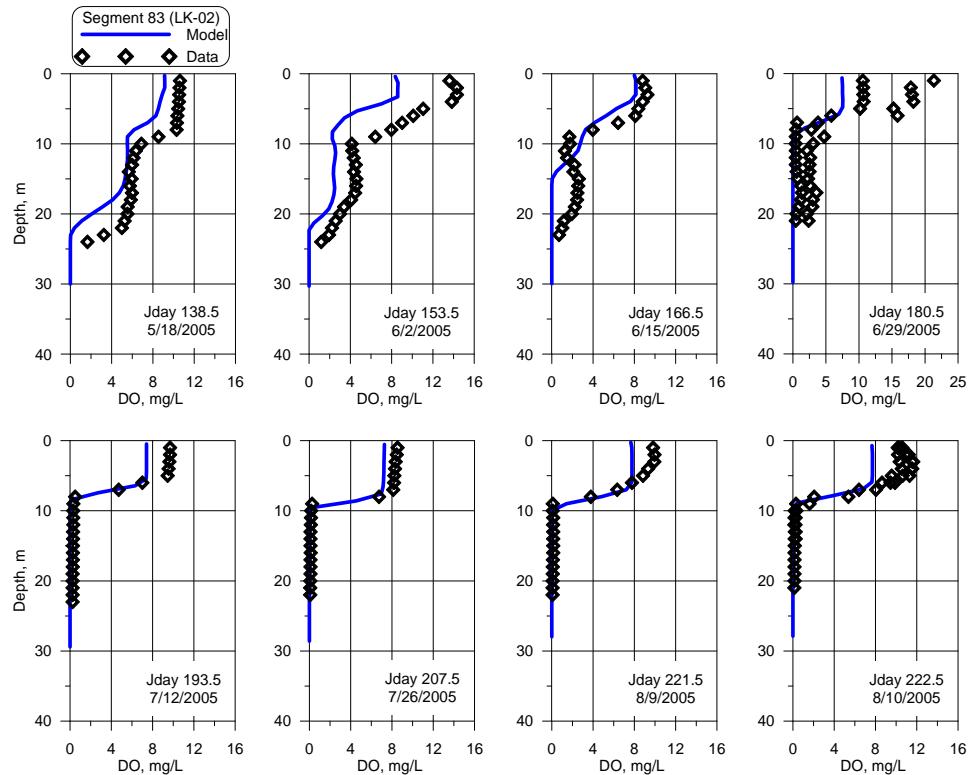


Figure 227. Dissolved oxygen profiles segment 83 Part 1.

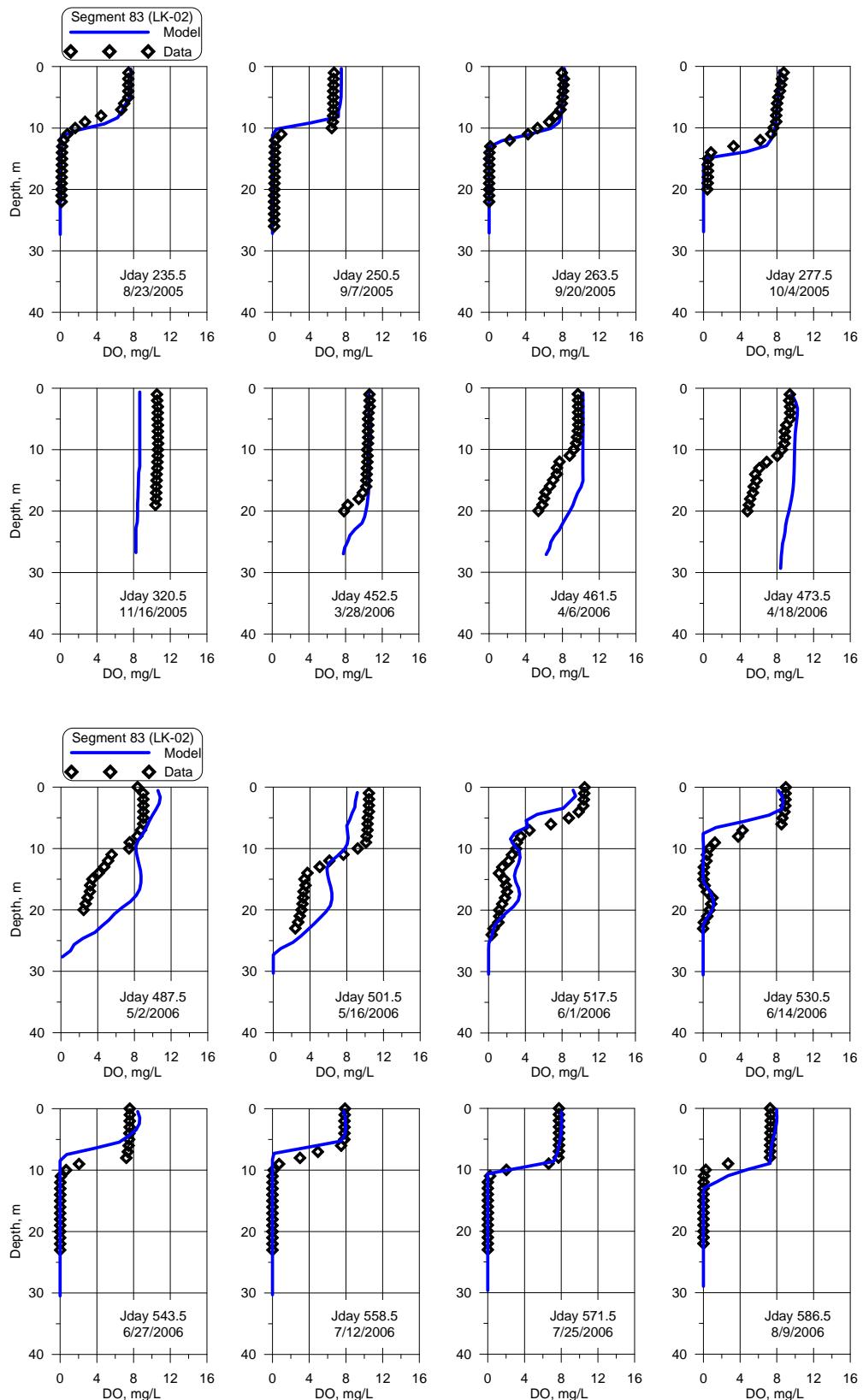


Figure 228. Dissolved oxygen profiles segment 83 Parts 2 & 3.

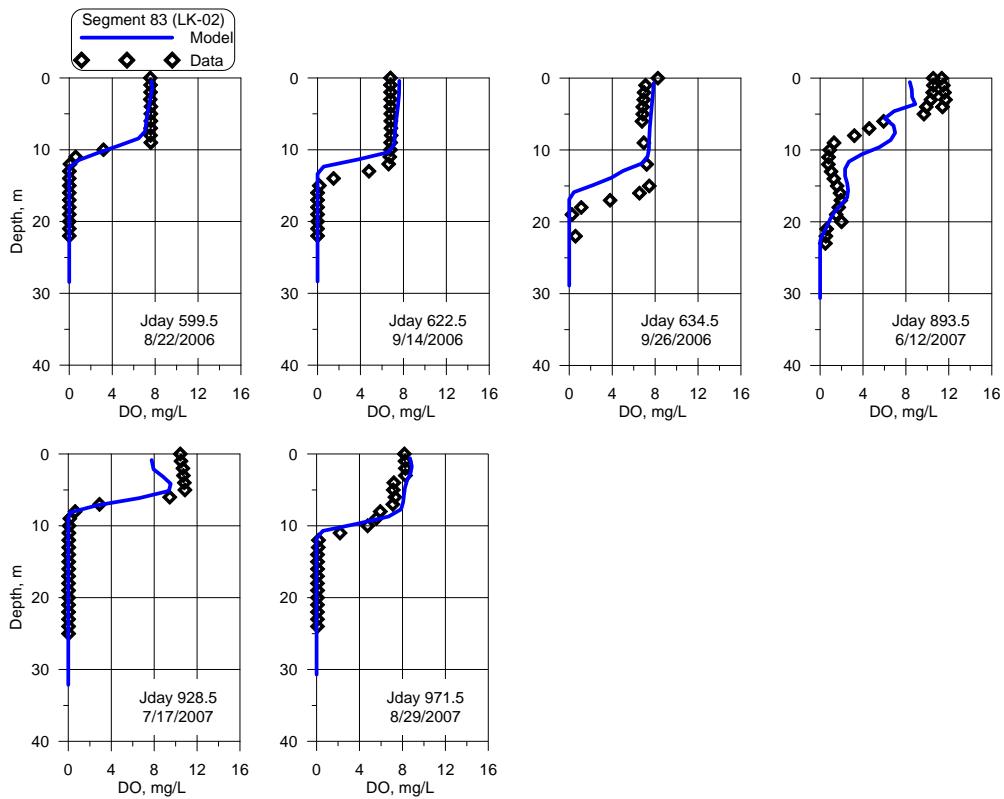


Figure 229. Dissolved oxygen profiles segment 83 Part 4.

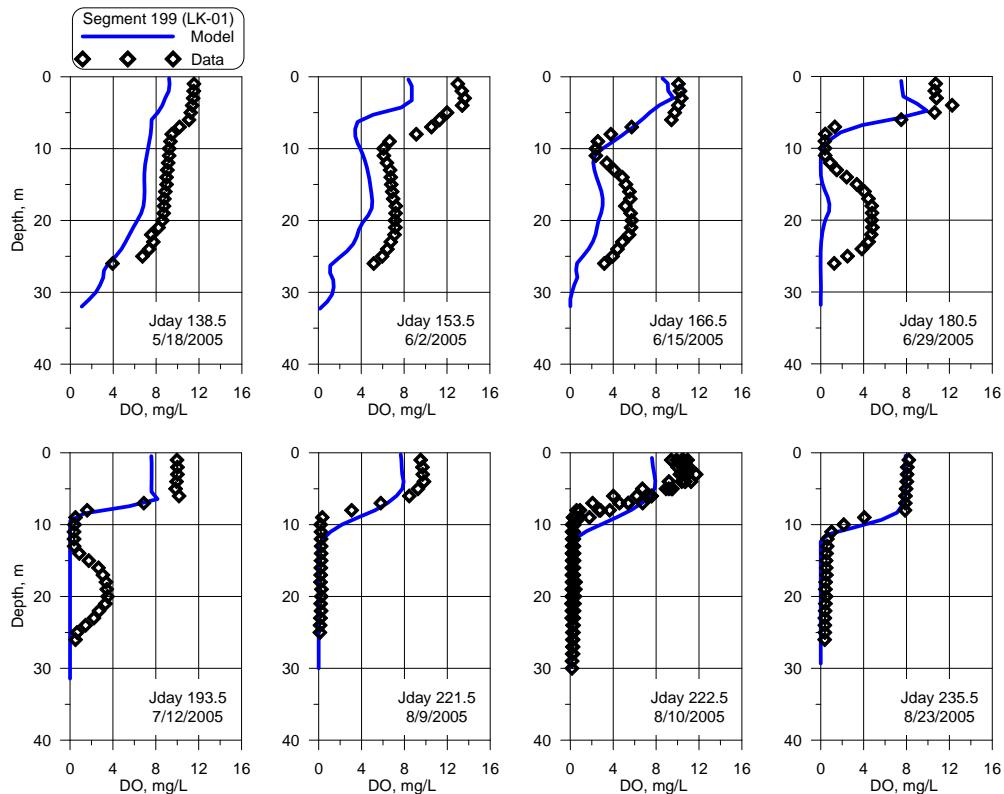


Figure 230. Dissolved oxygen profiles segment 199 Part 1.

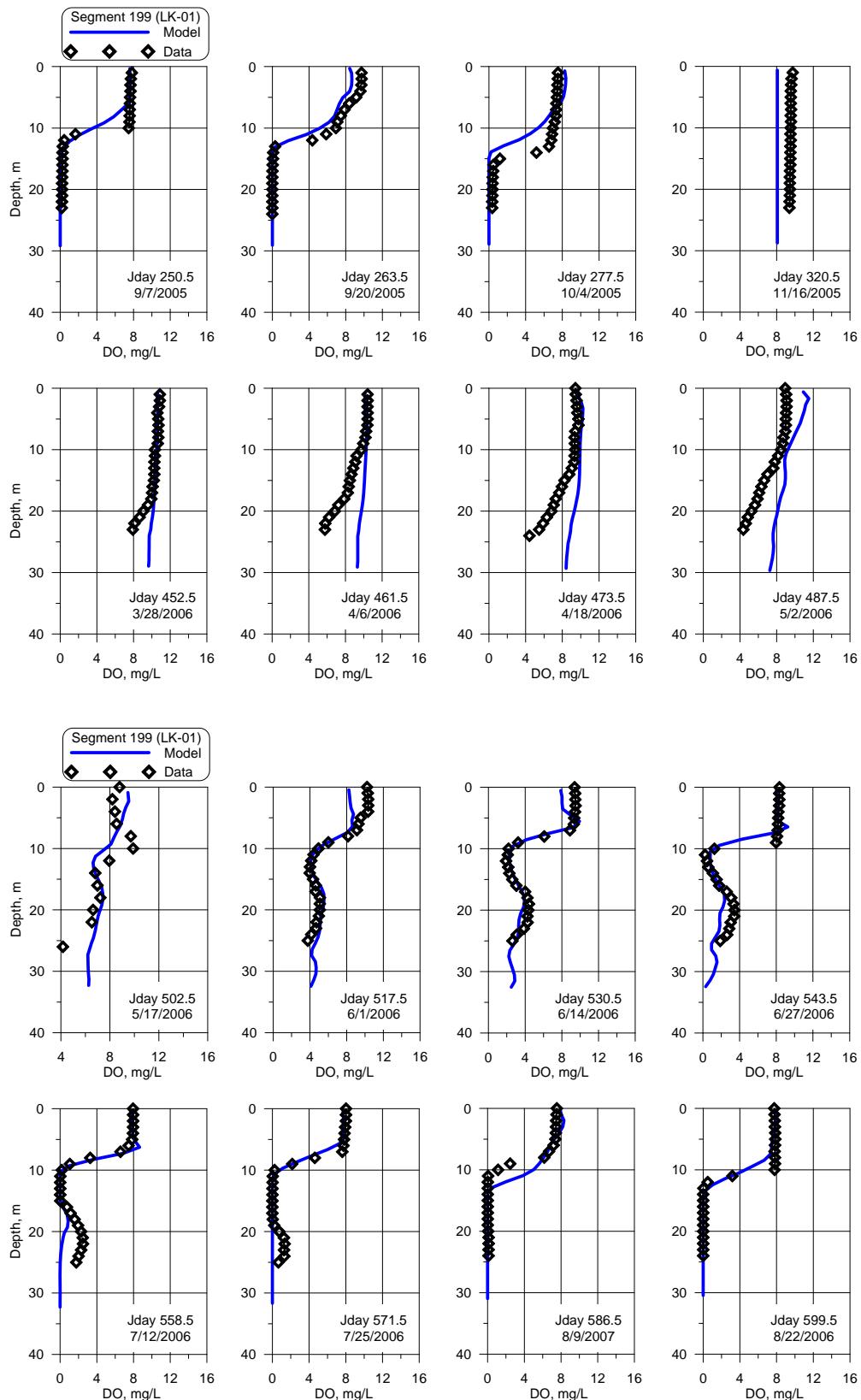
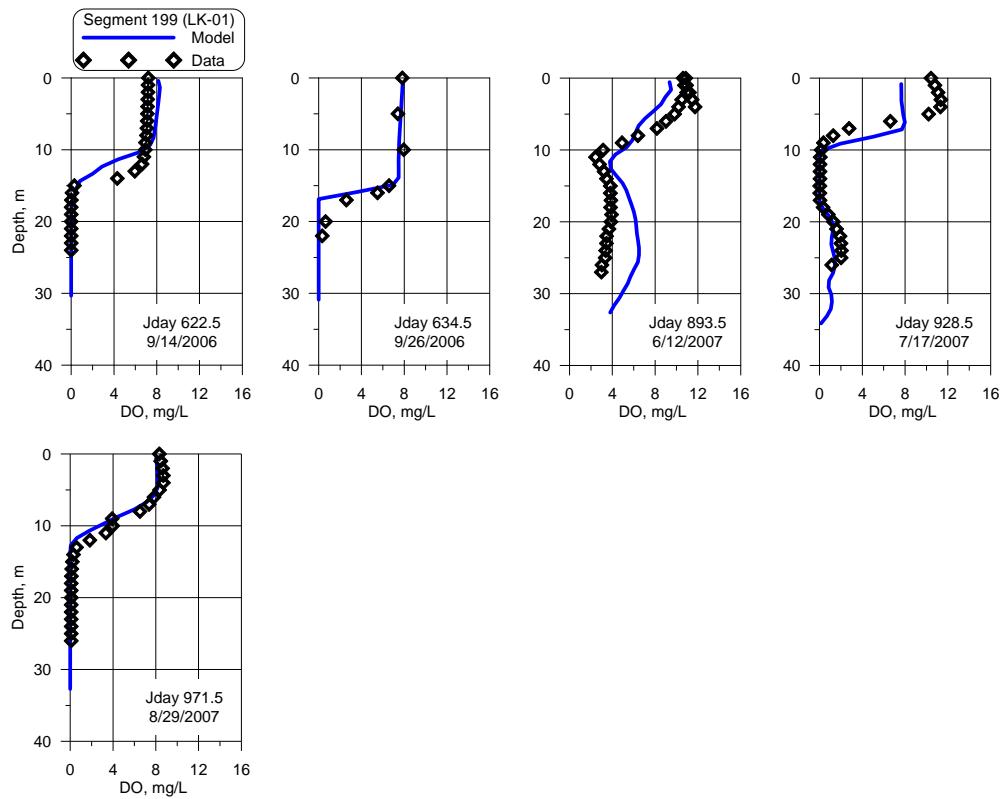
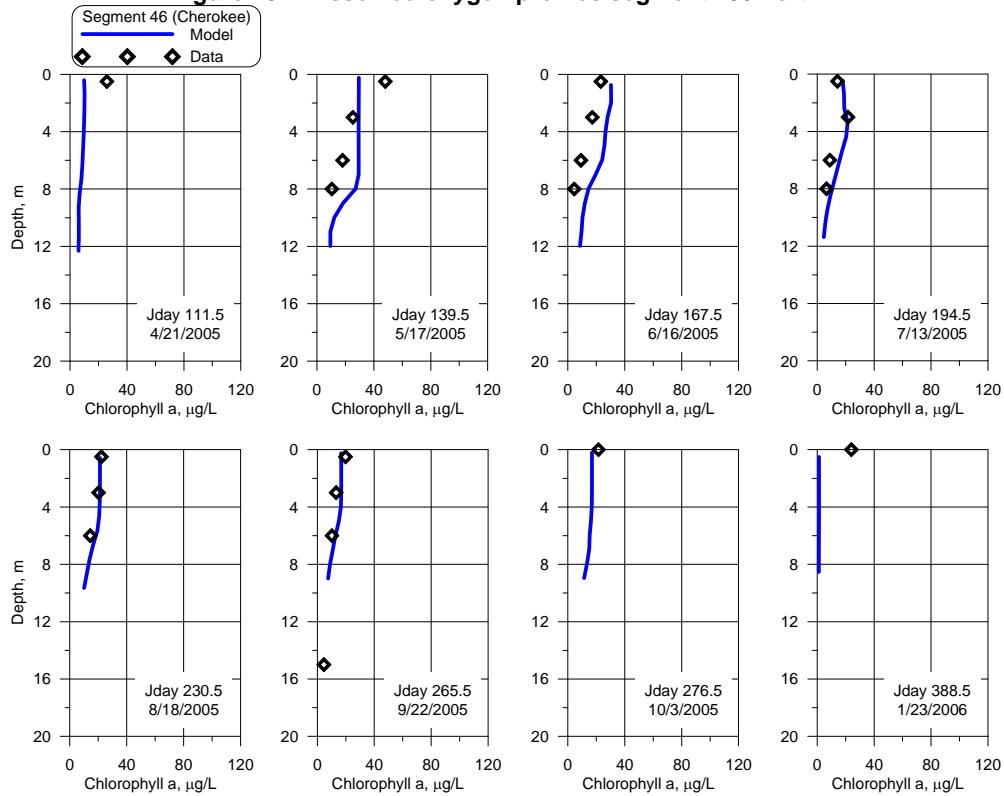


Figure 231. Dissolved oxygen profiles segment 199 Parts 2 & 3.

**Figure 232. Dissolved oxygen profiles segment 199 Part 4.****Figure 233. Chlorophyll a model vs. data profile – segment 46 during calibration period.**

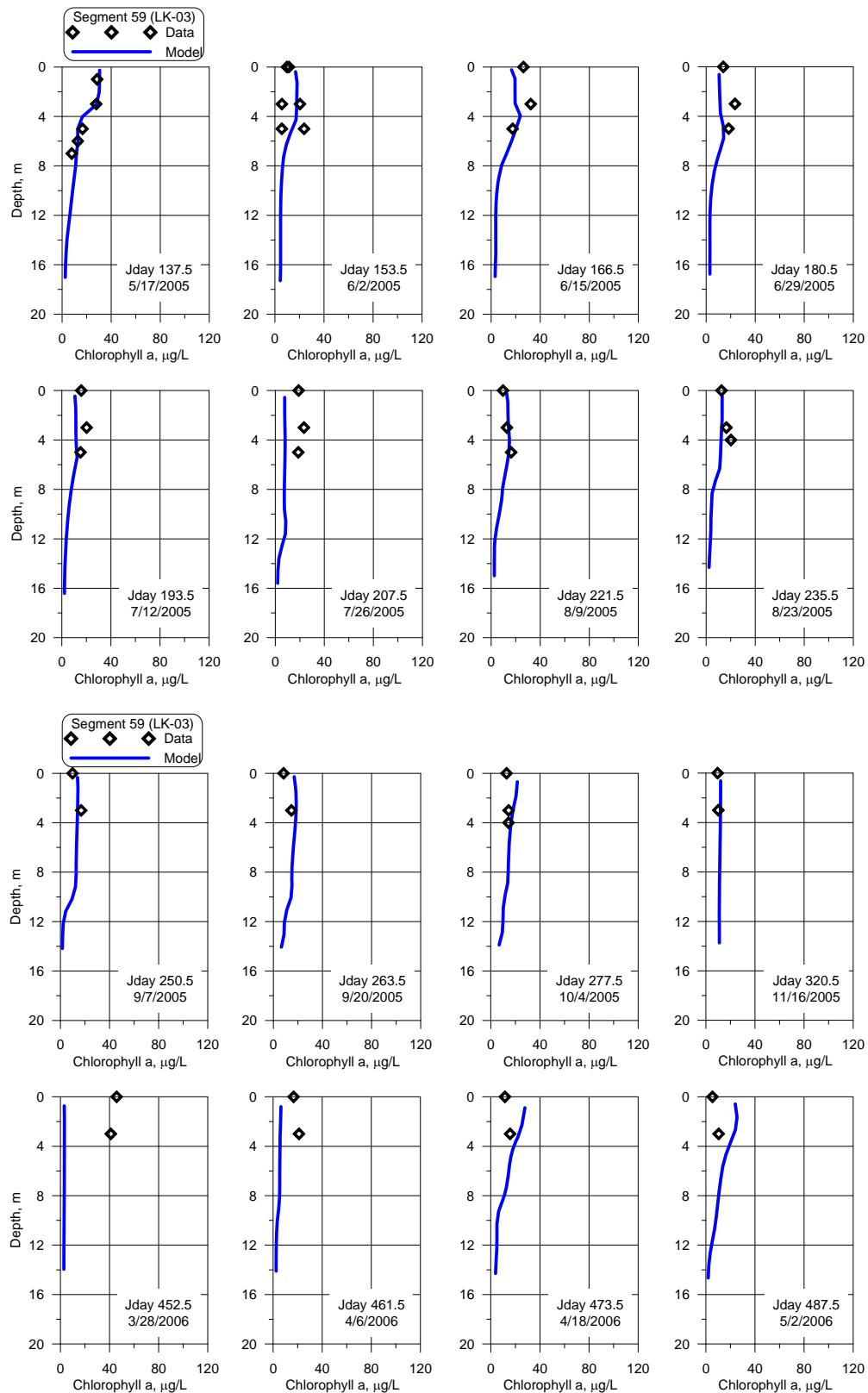


Figure 234. Chlorophyll a model vs. data profile – segment 59 Parts 1 & 2 during calibration period.

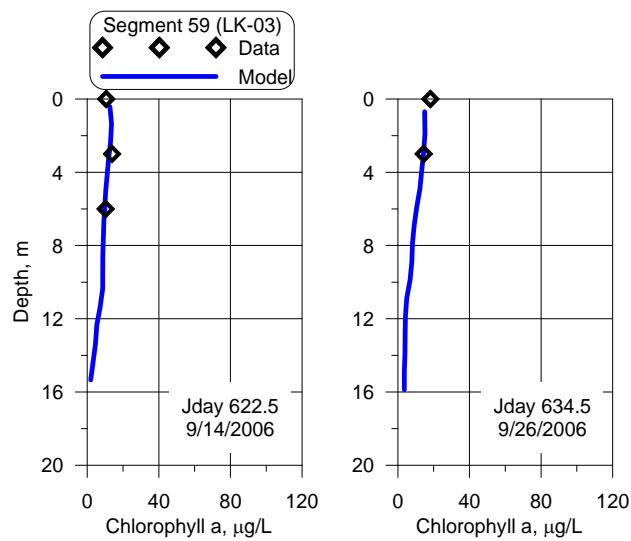
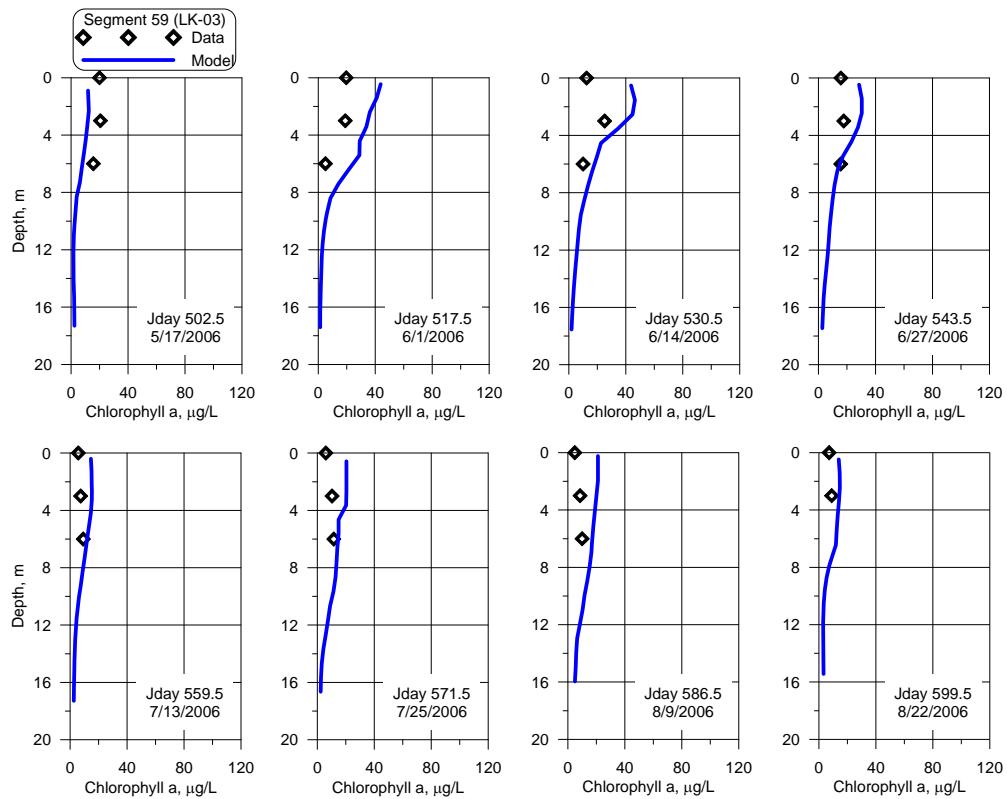


Figure 235. Chlorophyll a model vs. data profile – segment 59 Parts 3 & 4 during calibration period.

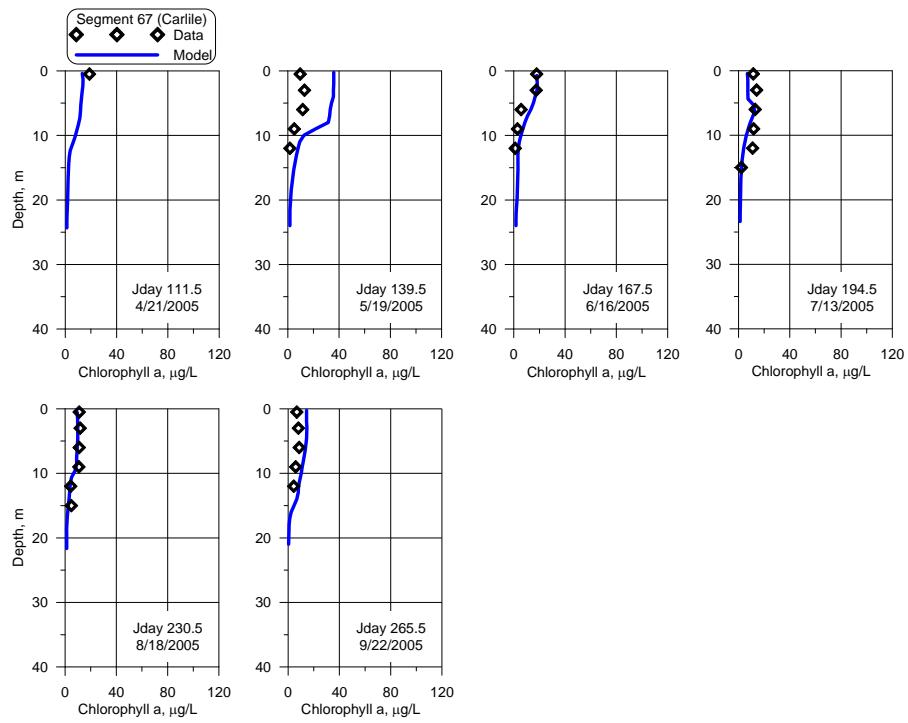


Figure 236. Chlorophyll a model vs. data profile – segment 67 during calibration period.

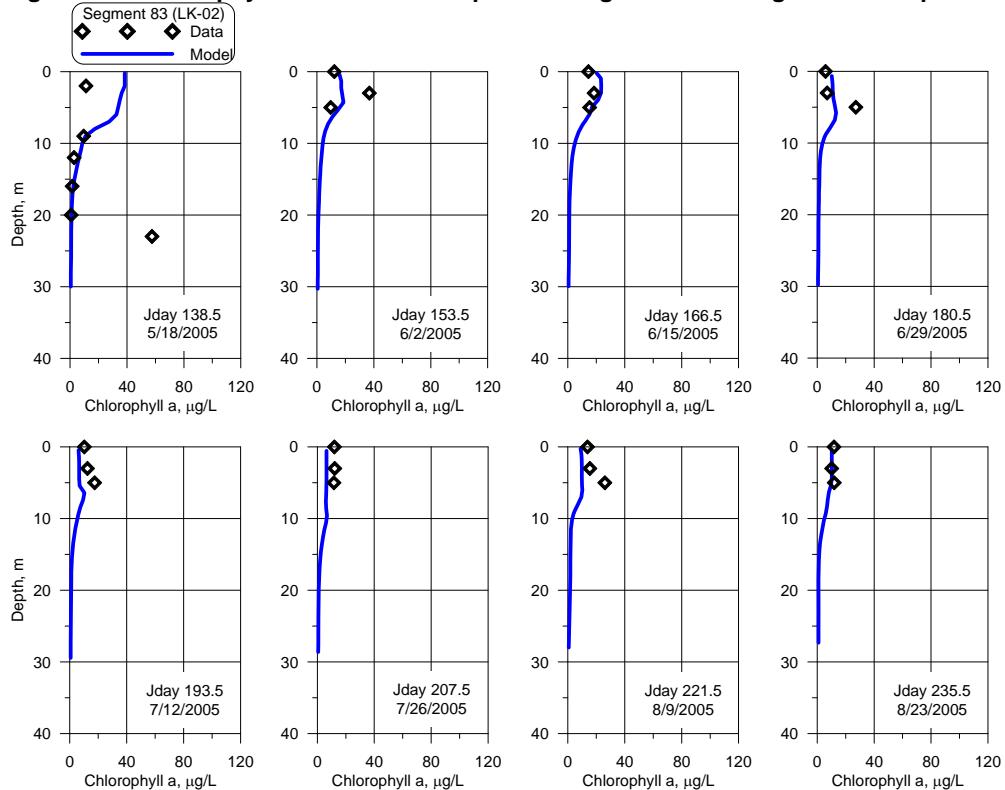


Figure 237. Chlorophyll a model vs. data profile – segment 83, Part 1 during calibration period.

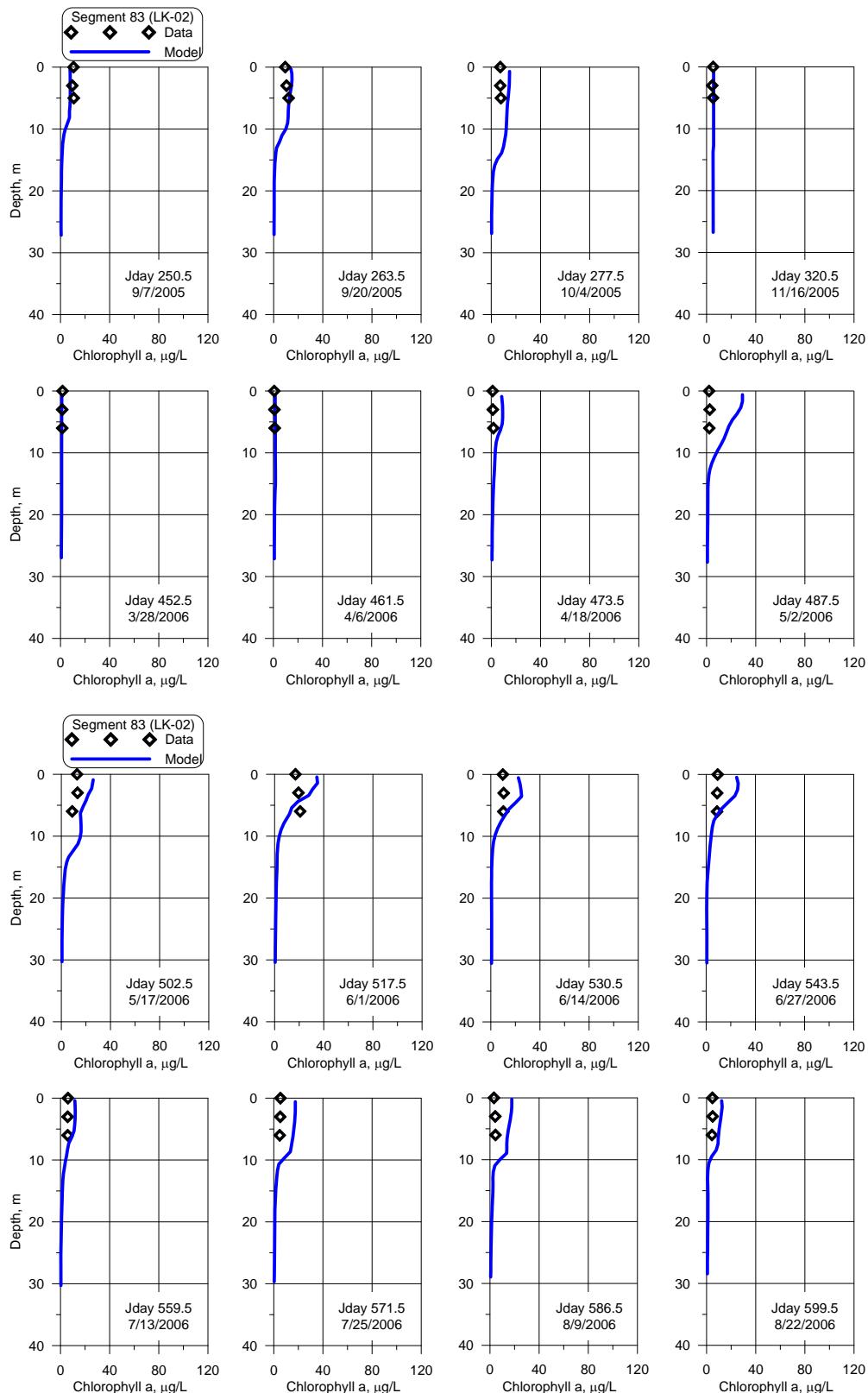


Figure 238. Chlorophyll a model vs. data profile – segment 83 Parts 2 & 3 during calibration period.

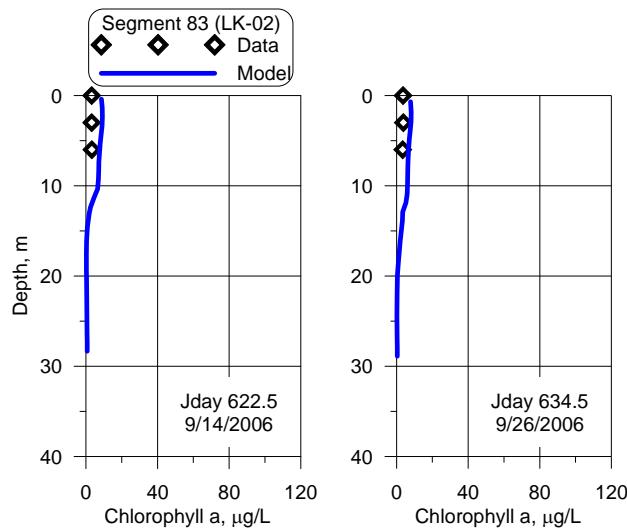


Figure 239. Chlorophyll a model vs. data profile – segment 83 Part 4 during calibration period.

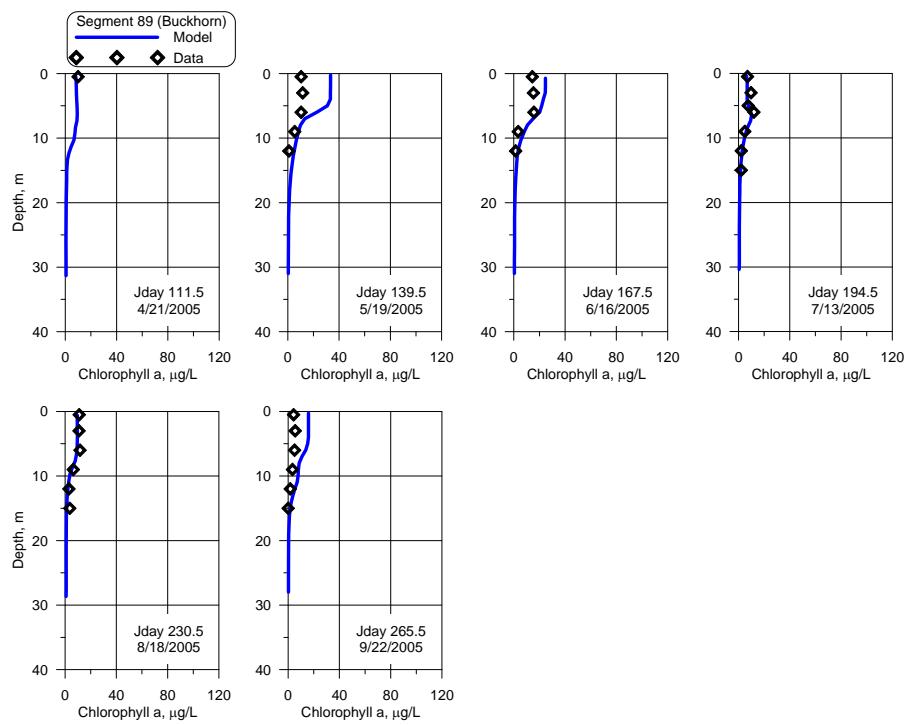


Figure 240. Chlorophyll a model vs. data profile – segment 89 during calibration period.

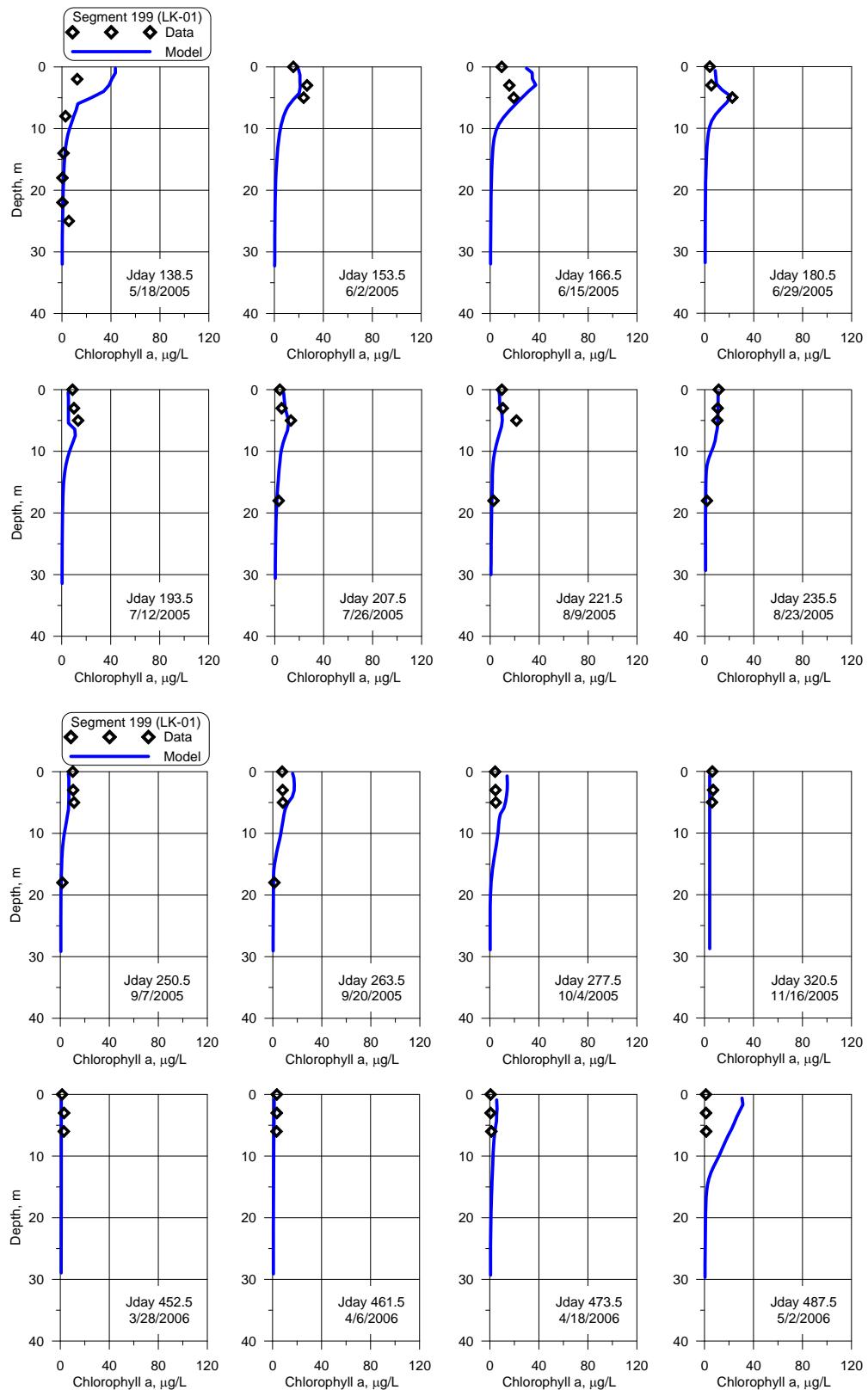


Figure 241. Chlorophyll a model vs. data profile – segment 199 Parts 1 & 2 during calibration period.

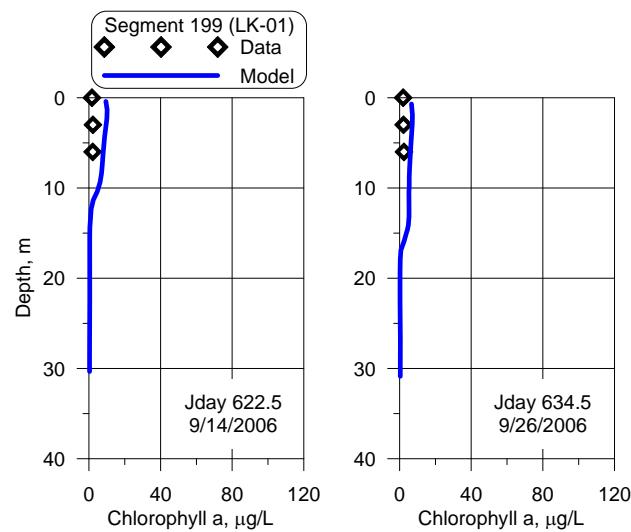
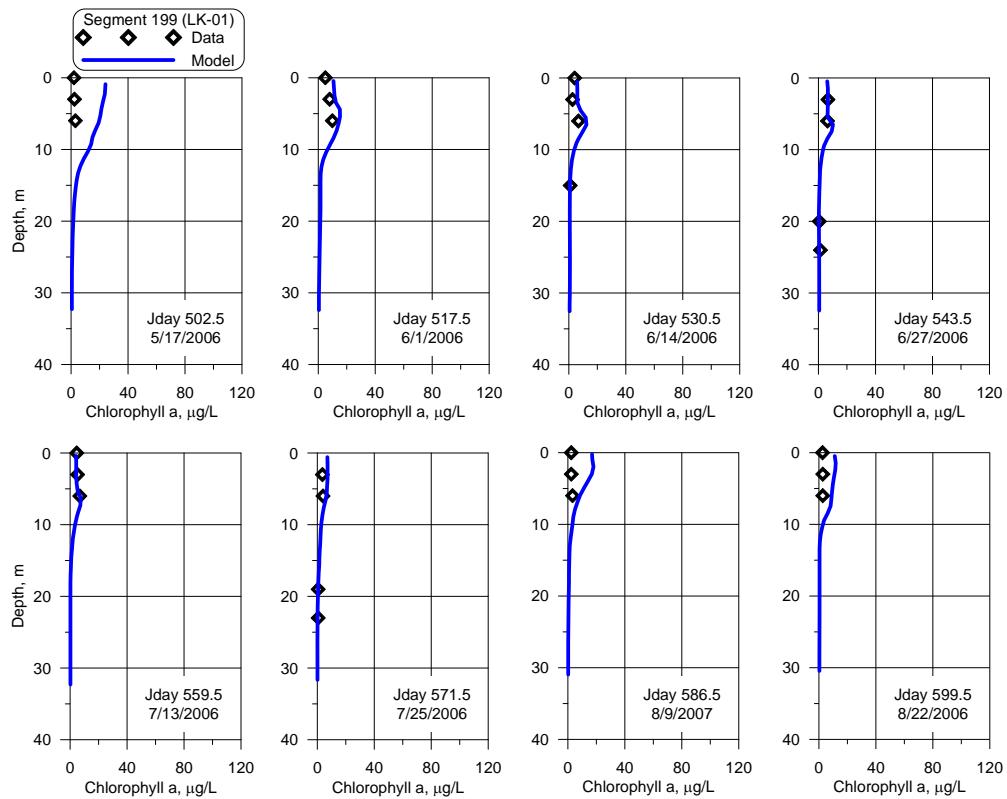


Figure 242. Chlorophyll a model vs. data profile – segment 199 Parts 3 & 4 during calibration period.

Updated Tables

Table 6. Model-data error statistics for temperature.

Model segment #	Lake sampling station	# of profiles	ME, °C*	AME, °C*	RMS error, °C*
35	LK04	24	-0.60	1.05	1.15
59	LK03	30	-0.05	0.58	0.68
83	LK02	30	0.14	0.76	0.91
109	LK05	3	-0.55	0.62	0.75
199	LK01	30	0.22	0.78	0.92
Weighted average of all observations			-0.06	0.78	0.90

* For definitions of ME: mean error, AME: absolute mean error, and RMS: root mean squared error, see Appendix C.

Table 9. Model-data error statistics for dissolved oxygen.

Model segment #	Lake sampling station	# of profiles	ME, mg/l *	AME, mg/l*	RMS error, mg/l*
35	LK04	25	-0.66	2.03	2.30
59	LK03	31	-1.17	1.79	2.04
83	LK02	30	-0.32	1.20	1.67
109	LK05	8	-0.39	1.20	1.51
199	LK01	30	-0.45	1.17	1.50
Weighted averages			-0.636	1.51	1.84

* For definitions of ME: mean error, AME: absolute mean error, and RMS: root mean squared error, see Appendix C

Table 14. Time averages of the Total P between model runs over the 50-year period.

Total P 50 year mean				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	0.087	0.042	0.044	0.046
Growth	0.147	0.077	0.073	0.075
Moratorium on P loading SOD decay = 0.1 g/m ² /d	0.051	0.023	0.023	0.024
Moratorium on P Loading, SOD decays over time	0.050	0.023	0.023	0.025
Natural	0.006	0.004	0.003	0.003
Historical	0.058	0.022	0.02	0.021
Cessation of P loading	0.051	0.024	0.024	0.026

Table 15. Median of the Total P between model runs over the 50-year period.

Total P 50 year median				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	0.081	0.025	0.022	0.028
Growth	0.141	0.062	0.051	0.056
Moratorium on P loading SOD decay = 0.1 g/m ² /d	0.048	0.014	0.011	0.013
Moratorium on P Loading, SOD decays over time	0.048	0.013	0.011	0.013
Natural	0.006	0.002	0.002	0.002
Historical	0.056	0.019	0.014	0.015
Cessation of P loading	0.048	0.014	0.011	0.014

Table 16. Time averages of the Total P between model runs over the last 10-year period.

Total P years 41-50 mean				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	0.087	0.042	0.041	0.044
Growth	0.193	0.104	0.093	0.101
Moratorium on P loading SOD decay = 0.1 g/m ² /d	0.040	0.018	0.015	0.017
Moratorium on P Loading, SOD decays over time	0.040	0.018	0.016	0.017
Natural	0.006	0.004	0.003	0.003
Historical	0.098	0.036	0.035	0.041
Cessation of P loading	0.041	0.019	0.016	0.019

Table 17. Median of the Total P between model runs over the last 10-year period.

Total P years 41-50 median				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	0.081	0.026	0.024	0.027
Growth	0.184	0.080	0.068	0.080
Moratorium on P loading SOD decay = 0.1 g/m ² /d	0.039	0.011	0.008	0.011
Moratorium on P Loading, SOD decays over time	0.039	0.011	0.009	0.011
Natural	0.006	0.002	0.002	0.002
Historical	0.093	0.031	0.020	0.020
Cessation of P loading	0.039	0.012	0.009	0.012

Table 18. Time averages of the chlorophyll a between model runs over the 50-year period.

Chlorophyll a 50 year mean				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	32.9	36.3	20.1	16.6
Growth	29.6	46.5	26.2	21.5
Moratorium on P loading SOD decay = 0.1 g/m ² /d	30.3	24.3	14.8	11.9
Moratorium on P Loading, SOD decays over time	30.4	24.3	14.9	11.9
Natural	6.6	3.6	2.0	1.6
Historical	9.5	24.2	13.1	11.0
Cessation of P loading	30.4	25.4	15.5	12.3

Table 19. Median of the chlorophyll a between model runs over the 50-year period.

Chlorophyll a 50 year median				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	35.0	27.4	12.4	11.5
Growth	30.8	40.4	17.4	15.2
Moratorium on P loading SOD decay = 0.1 g/m ² /d	33.5	17.3	7.0	5.7
Moratorium on P Loading, SOD decays over time	33.6	17.6	6.8	5.6
Natural	6.5	2.6	0.9	0.6
Historical	6.7	23.2	9.9	8.0
Cessation of P loading	33.6	18.5	7.3	6.4

Table 20. Time averages of the chlorophyll a between model runs over the last 10-year period.

Chlorophyll a years 41-50 mean				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	34.0	36.8	20.3	15.6
Growth	28.5	54.9	31.8	24.8
Moratorium on P loading SOD decay = 0.1 g/m ² /d	28.4	20.4	12.4	9.7
Moratorium on P Loading, SOD decays over time	28.2	20.5	12.6	9.8
Natural	6.6	3.7	2.0	1.4
Historical	4.5	38.5	19.0	14.0
Cessation of P loading	28.6	22.1	14.1	10.7

Table 21. Median of the chlorophyll a between model runs over the last 10-year period.

Chlorophyll a years 41-50 median				
Scenario	Sampling Site LK04, segment 35	Sampling Site LK03, Segment 59	Sampling Site LK02, Segment 83	Sampling Site LK01, Segment 109
Base	37.5	29.3	12.6	11.9
Growth	30.1	50.5	19.3	19.1
Moratorium on P loading SOD decay = 0.1 g/m ² /d	31.5	15.0	5.7	5.2
Moratorium on P Loading, SOD decays over time	31.5	15.0	4.6	4.3
Natural	6.5	2.6	0.9	0.6
Historical	4.7	33.1	17.0	12.2
Cessation of P loading	31.7	16.1	6.7	6.0

Table 22. Average of May-October outlet dissolved oxygen concentrations.

Simulation	Average summer flow weighted DO between May 1 and October 31 <i>over entire 50 yr period</i>	Average summer flow weighted DO <i>between May 1 and October 31 – over last 10 years</i>
Base case – P loading as is	1.31 mg/l	1.29 mg/l
Cessation, SOD gradual decline to 0.1 g/m ² /d	2.24 mg/l	2.52 mg/l
Natural conditions	6.10 mg/l	6.02 mg/l
Growth	1.17 mg/l	1.06 mg/l
Historical	3.84 mg/l	2.71 mg/l

Table 25. Habitat volume for small mouth bass and walleye for summer (June 15 through September 15) over the 50-year simulation.

Model run	% Total habitat volume - Small mouth bass optimal	Habitat volume (m ³)-Small mouth bass optimal	% Total habitat volume Small mouth bass suboptimal	Habitat volume (m ³)-Small mouth bass suboptimal	% Total habitat volume Walleye suboptimal	Habitat volume (m ³)-Walleye suboptimal
Base case - P loading as is – Mean 50 years	8.14	0.62336E+08	33.17	0.24663E+09	1.47	0.11060E+08
Base case - P loading as is – Standard deviation 50 years	4.03	0.30287E+08	12.74	0.92779E+08	1.90	0.14044E+08
Cessation, SOD changed to 0.1 g/m ² /d – Mean 50 years	10.07	0.76891E+08	36.72	0.27333E+09	2.86	0.21435E+08
Cessation, SOD changed to 0.1 g/m ² /d – Standard deviation 50 years	5.00	0.36655E+08	13.68	0.98612E+08	3.64	0.26505E+08
Natural Mean 50 years	23.02	0.17504E+09	55.38	0.41399E+09	13.87	0.10306E+09
Natural Standard deviation 50 years	7.18	0.49749E+08	13.90	0.99122E+08	7.99	0.55332E+08
Growth – Mean 50 years	7.79	0.59316E+08	31.68	0.23490E+09	1.49	0.11111E+08
Growth – Standard deviation 50 years	4.41	0.32569E+08	12.16	0.88388E+08	2.43	0.17663E+08
Historical - Mean 50 years	9.35	0.63071E+08	36.72	0.24494E+09	1.56	0.10632E+08
Historical – standard deviation 50 years	5.82	0.37881E+08	14.38	0.93766E+08	2.92	0.20101E+08

Table 27: Summary of Total P outflow from Tenkiller Reservoir.

	Average P Outflow from Dam, kg/day	P Outflow % of Base Case
Base Case	462	100%
Growth Scenario	638	138%
Cessation Scenario 1 - SOD=0.1 g/m ² /day	273	59%
Cessation Scenario 2- SOD declines to 0.1 g/m ² /day	279	60%
Historical Case	285	62%
Natural Case	42	9%

Table 28: Summary of Total P sediment flux.

Scenario	SED, kg/50yr	SOD, kg/50yr	Total kg/50yr	Daily Average In Model Production, kg/day
Base Case	1480392	1473407	2953799	162
Growth	1656402	1670131	3326533	182
Cessation SOD = 0.1 g/m ² /day	1123590	133972	1257562	69
Cessation SOD declines to 0.1 g/m ² /day	1128444	254146	1382590	76
Historical	903300	115853	1019153	56
Natural	203931	16373	220304	12

Table 29. Change in chlorophyll a over time during the 50-year period for the cessation, growth, and historical runs. Trends are only for summer periods between June 1 and September 30.

Scenario	Lake Station	Slope, chlor a $\mu\text{g/l/year}$	Intercept, chlor a in $\mu\text{g/l}$	% change over 50 years	Standard error of estimate, $\mu\text{g/l}$ chlor a
Cessation	LK04	-0.192	35.28	-27.2	15.8
Cessation	LK03	-0.2337	30.29	-38.6	13.2
Cessation	LK02	-0.12206	17.98	-33.9	15.1
Cessation	LK01	-0.1174	14.91	-39.4	12.8
Historical	LK03	0.55421	10.03	276.3	11.1
Historical	LK02	0.1725	8.73	98.8	9.3
Historical	LK01	0.05358	9.66	27.7	10.5
Growth	LK04	-0.1708	33.99	-25.1	18.4
Growth	LK03	0.259	36.08	35.9	16.3
Growth	LK02	0.1321	19.82	33.3	19.2
Growth	LK01	0.07186	17.67	20.3	16.1

Table 30. Change in Total P over time during the 50-year period for the cessation, growth, and historical runs. Trends are only for summer periods between June 1 and September 30.

Scenario	Lake Station	Slope, Total P in mg/l/year	Intercept, Total P in mg/l	% change over 50 years	Standard error of estimate, Total P in mg/l
Cessation	LK04	-0.0005537	0.064589	-42.9	0.014
Cessation	LK03	-0.0002965	0.03065	-48.4	0.022
Cessation	LK02	-3.70E-04	0.0323	-57.3	0.025
Cessation	LK01	-0.0003469	0.033366	-52.0	0.027
Historical	LK04	0.001654	0.015885	520.6	0.013
Historical	LK03	0.000511	0.0089	287.1	0.015
Historical	LK02	0.000538	0.006534	411.7	0.019
Historical	LK01	0.0006	0.0061	491.8	0.021
Growth	LK04	0.002255	0.08436	133.7	0.028
Growth	LK03	0.0014	0.03633	192.7	0.050
Growth	LK02	0.001022	0.03582	142.7	0.046
Growth	LK01	0.001138	0.0325	175.1	0.035

Table 31. Change in outlet dissolved oxygen over time during the 50-year period for the base, cessation (SOD decline), growth, and historical runs between June 1 and September 30.

Scenario	Average outlet dissolved oxygen, mg/l	Slope, DO in mg/l/year	Intercept, DO in mg/l	% change over 50 years	Standard error of estimate, in mg/l dissolved oxygen
Base	1.3	-0.00261	1.3803	-9.5	1.0
Cessation	2.2	0.02044	1.715	59.6	1.5
Growth	1.2	-0.007654	1.3635	-28.1	0.9
Historical	3.8	-0.079	5.8577	-67.4	1.6